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Ecology Of The Spotted Turtle, Clemmys Guttata At The Western Range Limit

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Ecology of the Spotted turtle, Clemmys guttata at the Western range limit.

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Thomas P. Wilson

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ABSTRACT

Clemmys guttata is a northeastern and coastal species which reaches the western range limit in Illinois. Three small populations of this species occur along the Des Plaines River in Will Co., IL. The ecology of a northern Illinois population of Spotted turtles, *Clemmys guttata*, was investigated using capture-recapture and biotelemetric techniques from May 1992 to June 1993 at Lockport Nature Preserve in Will Co. This study was conducted to gather the ecological data necessary to design a management plan for the species. These research criteria included extent of turtle movements within the study site, habitat use, estimate population size, determine annual activity cycle, estimate average home range, and determine how the ecology of this species in Illinois differs from eastern populations.

Turtles were captured by hand or muddling. A total of 98 turtles have been captured at the Lockport site. Population size was estimated at 115 turtles using the Schnabel method from recapture data. Population density was calculated to be 2.2 turtles/ha via the Schnabel method.

Radiotelemetry was used to follow the movements of eight adult spotted turtles. Lockport spotted turtle's home ranges averaged 1.36 ha. Females had significantly larger home ranges than males. Terrestrial long distance movements were restricted to nesting females and core areas within the home range shifted

seasonally. In Illinois this turtle is closely associated with cattail marsh and sedge meadow habitat.

Spotted turtles were diurnal except for nesting females. Annually the turtles emerge from brumation in March; are active until late June; aestivate from July to September; are active for shorter periods from October to early November; and enter brumation in late November and December. Peak activity periods were correlated with temperature and changed seasonally. Typically, turtles were active until their core temperatures reached the mean preferred temperature (21-25 C), and above that they retreat to the water or shade. Biophysical temperatures were taken to determine the relationship between cloacal and environmental temperatures. Cloacal temperatures of spotted turtles ranged form 4.4 C to 33.0 C. Cloacal temperatures varied depending upon the ambient temperature and behavior, but were strongly correlated to the environmental temperature that was in close association with the turtle.

Lockport spotted turtles were observed copulating from March through May. Nesting was observed from June 18 to 26. A single clutch is laid containing 3 to 5 eggs with hard expansible shells.

Turtles grew rapidly through the early years but growth rates leveled off at seven years (approximate age of maturity). Males were significantly larger than females at age classes 2-6. Shell abnormalities of several types occurred among members of this population including supernumerary scutes, cracking, and erosion of scutes. Causes may include inbreeding and/or environmental factors.

Some factors that may attribute to mortality are predation by nocturnal mammalian predators and/or burning of the site in early spring. No spotted turtles were found dead at the Lockport site during 1992. However, several individuals showed signs of predator encounters. Several individuals showed apparent fire damage primarily on the carapace. Causal factors limiting the range of the spotted turtle in Illinois are discussed along with management recommendations.

Dedicated to the Spotted turtles Clemmys guttata of the Lockport Prairie Nature Preserve.

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Thomas P. Wilson
July 2, 1994
Remember it's all turtles!!

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INTRODUCTION

The spotted turtle (*Clemmys guttata*) is semi-aquatic and generally inhabits marshes and sedge meadows through the northeastern United States (Ernst and Barbour, 1989). This species is widely distributed, extending from Ontario to southern Georgia and northern Florida, and from the Atlantic coast west to northeastern Illinois (Ernst, 1972a). During the late 1800's the range probably included much of the Chicago metropolitan area. Garman (1892) suspected this eastern species might exist in Illinois. However, Cahn collected the first state specimens in 1927 (Cahn, 1937). Originally the turtle was thought to exist only in Cook Co., but later it was discovered in Will Co. The ecology of this turtle has never been comprehensively studied in Illinois, the western limit of its range (Smith, 1961). No Cook Co. specimens have been found in recent times despite searches by several researchers. Today this turtle is an endangered species in Illinois (Herkert, 1992) and its known range is limited to three small sites along the Des Plaines River in Will Co. One of these sites is currently in jeopardy due to industrial expansion (Mauger and Stillwaugh, 1991). The remaining two populations are considerably larger and are protected within two Illinois nature preserves, the Lockport Nature Preserve and the Romeoville Nature Preserve.

The first spotted turtles were observed at Lockport in 1982 (Pers. Comm. Mauger, 1992). Initial studies of the Illinois spotted turtle populations were conducted by Capler and Moll (1988) in the Lockport Prairie Nature Preserve and McGee, et al. (1989) in the Romeoville Nature Preserve. The study described herein is continuation of the 1988 Lockport study. The purpose of this study was mild water pepper (*P. hydropiperoides*). Sparse amounts of duckweed (*Lemna sp.*) are present. The wetland meadows are comprised of numerous species, including sedges (*Carex sp.*), big blue stem (*Andropogon gerardii*), little blue stem (*Schizachyrium scoparius*), indian grass (*Sorghastrum nutans*), cord grass (*Spartina pectinata*), switch grass (*Panicum virgatum*), bulrushes (*Scirpus sp.*) and spike rush (*Eleocharis obtusa*). The federally endangered leafy prairie clover (*Petalostemum foliosum*) is also found there (Herkert, 1991). Other rare and unusual plants that occur at the site are low calamint (*Satureja arkansana*), slender sandwort (*Arenaria patula*) and Ohio horsemint (*Blephilia ciliata*). Prairie satin grass (*Muhlenbergia cuspidata*) is considered quite rare (in Illinois) and has been thriving in a large population at the site (McFall, 1991; Pers. Comm. DeMauro-Roth and Mauger, 1992). Primary habitat types include dry dolomite prairie (1), dry mesic dolomite prairie (2), mesic dolomite prairie (3), wet mesic dolomite prairie (4), wet dolomite prairie (5), cattail marsh (6), sedge meadow (7), graminoid fen (8), flood plain forest (9) and successional-cultural (10) (DeMauro, 1986; and DeMauro-Roth and Mauger, 1992) (See Appendix A).

Amphibians and reptiles associated with the Spotted turtle at the site include cricket frogs (*Acris crepitans*), American toads (*Bufo americanus*), common snapping turtles (*Chelydra serpentina),* painted turtles (*Chrysemys picta*), Kirtland's watersnake (*Clonophis kirtlandi*), western foxsnakes (*Elaphe vulpina*), Blanding's turtles (*Emydoidea blandingi*), eastern kingsnakes (*Lampropeltis triangulum*), northern watersnakes (*Nerodia sipedon*), smooth green snakes (*Opheodrys vernalis*), western chorus frogs (*Pseudacris triseriata*), bullfrogs (*Rana catesbeiana*), greenfrogs (*Rana clamitans*), northern leopardfrogs (*Rana pipiens*), queensnake (*Regina septemvittata*), stinkpot turtles (*Sternotherus odoratus*), plains garter snakes (*Thamnophis radix*) and eastern garter snakes (*Thamnophis sirtalis*). The eastern massasauga rattlesnake (*Sistrurus catenatus*), an endangered species in Illinois, may exist at the Lockport site, but no specimens have been collected.

The Lockport site is also rich in other species of vertebrates. Numerous species of waterfowl, songbirds, shorebirds and birds of prey utilize this wildlife habitat. Mammals known to utilize this area are raccoon (*Procyon lotor*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), eastern cottontail rabbit (*Sylvilagus floridana*), white tailed deer (*Odocoileus virginianus*), voles (*Microtus sp.*) and several species of mice (*Peromyscus sp.*). Besides vertebrate fauna the site has varied invertebrate life. Occurring at Lockport is a large population of Hine's emerald dragonflies (*Somatochlora hineana*), a federally endangered species which only exists at a few other localities in Illinois and Wisconsin (Pers. Comm. Mauger, 1992; Pers. Comm. Cashatt, and Whitten, 1994).

METHODS AND MATERIALS

The study was conducted for 134 days from 10 May 1992 to 27 June 1993. Observations were made daily from 10 May to 14 August 1992, then bimonthly until January 1993 and then monthly until the completion of the project. Turtles were collected exclusively by hand or muddling between 0800 and 1600 h.

BIOTELEMETRY

Single stage radio transmitters (Custom Electronics, Urbana Illinois) were placed on 8 adult *Clemmys guttata* (3 males and 5 females) at the onset of the study. Transmitters were enclosed in paraffin or beeswax, encased in dental acrylic, and glued to the posterior edge of the carapace. No transmitter exceeded 5 percent of the turtles body weight (Reinert, 1992). Turtles were released at their capture site and radio-located daily.

Due to the size of the study site, it was not gridded. Rather, mapping locations were recorded and plotted on a large scale map (1"=30.8 m) prepared from aerial photographs. Conspicuous landmarks were used including telephone poles, railroad tracks, steel bridges, foot bridges, large rocks and trees. Several 6 meter long, orange fencing posts were strategically placed where natural land marks were absent. All reference points were plotted on the map as accurately as possible. Each relocation was marked with flagging tape on which the time, date and turtles identification number were recorded. Locations were identified by determining the distance and direction from the nearest land marker.

Home range was defined as the area that an animal utilizes through a given period (Burt, 1940). These were determined by the minimum convex polygon method (Mohr, 1947), and areas were calculated using a digitized computer mapping program via AUTOCAD 12 (Gilmer et al., 1973). Range length was calculated as the difference in the distance between the two most extreme points of location for each individual (Pluto and Bellis, 1988). Animals typically utilize certain areas more frequently than others, and avoid some areas completely (Sanderson, 1966). For this reason, core areas were then determined by the area encompassing 75 percent of the points nearest the major and minor axis of the polygon (Mohr and Stumpf, 1966). These can be determined by the distribution of plotted radio-locations throughout the season and/or year (Dixon and Chapman, 1980 and Rowe and Moll, 1991). Movement patterns lacking a central core area are considered transient movements (Samuel et al., 1985).

Upon relocating a turtle, the microhabitat was noted and described. Two preference indices (PI) were used to analyze microhabitat selection. One was based on percent usage/percent availability in the home range and the other was percent use/percent availability for the entire study site (Schemnitz, 1980). Percent usage was determined from the total number of new locations within a microhabitat (where an animal had shifted positions into a new location since its last relocation). Percent availability was calculated as the percent area of the total area occupied by each of the ten microhabitats. Roads, railroad right of ways, and microhabitats symbolized by "?" were not included in the total area.

Transitional areas (e.g. microhabitat 7-4t) were divided equally into the two parental microhabitats.

All (PI) values were then standardized from 0 to 1, for each turtle, by dividing every value by the highest value obtained. The standardized values ranged from no habitat preference or purposeful avoidance (0) to the most desirable microhabitat (1). Chi square tests were used to analyze microhabitat selection data, via the statistical program STATPAK (Northwest Analytical, Inc.); the null hypothesis (Ho): turtles randomly choose microhabitats; and the alternative hypothesis (Hi): turtles do not randomly choose microhabitats. Data from microhabitats 1-5, the dolomite prairie complex, were pooled together to generate expected values greater than five.

POPULATION ESTIMATION

Studies of the spotted turtle, *Clemmys guttata* have been conducted at Lockport prairie since 1988. Population data from Capler and Moll (1988) and Mauger (1990) were combined with current data from 1992-1993. Population data were complied from the following: 1) total number of marked individuals, 2) total number of newly marked individuals for the year, 3) total number of recaptures for the year, and 4) number of times a given individual is recaptured in a given year. Then population estimates were determined using the Schnabel method (ECOSTAT program, Trinity software).

THERMAL RELATIONSHIPS

Maximum and minimum thermometers were placed at a standard depth (12 cm) in the pond and read daily. Additional climatological data for Will Co. were obtained from the Illinois State Department of Commerce (Lovich, 1988). Upon relocating a turtle, cloacal and environmental temperatures were recorded (Ernst 1972b, 1977, 1982, 1986a, 1986b). Spotted turtles frequently void their bladders when probed for a cloacal temperature which can be detrimental during xeric periods (Ernst, 1968). Consequently, cloacal temperatures were taken weekly during periods of aestivation. Linear regression was used to determine the relationship between body and environmental temperatures.

Upon encountering brumating or aestivating turtles, the substrate temperature was taken to the nearest 0.2 C. Substrate temperatures for terrestrial locations were measured approximately 3-4 cm below the surface of the point adjacent to the rear/lateral side of the carapace (Ernst, 1982).

REPRODUCTION

Females were checked for reproductive condition by palpating the inguinal pocket for shelled eggs (Rowe and Moll, 1991). Gravid females were also X-rayed to determine the clutch size by the method developed by Gibbons and Greene (1979), and were radio-tracked to locate nest sites. Eggs were measured, photographed, described along with the nesting habitat, and each nest location was plotted on the site map. Approximate nest temperatures were taken weekly by placing a thermometer to a depth of 3-4 cm, and 12 cm from the periphery of the nest. Hardware cloth enclosures (18 gauge metal hardware cloth and 2.6 cm X 5.1 cm X 61.0 cm wooden frame) were used to cover the nest to retain hatchlings (Congdon et al., 1983) and deter predators (Moll and Legler, 1971). In addition, a single female experienced difficulty while nesting and was given an injection of oxytocin to aid in ovulation (Ewert and Legler, 1978).

GROWTH AND SHELL ABNORMALITIES

Captured turtles were photographed dorsally and ventrally and the following measurements taken after Carr (1952): carapace length (CL), carapace width (CW), plastron length (PL), shell height (H) and body mass (M). All measurements were straight line to the nearest 0.1 mm using dial calipers. Turtles were aged by counting growth annuli on an abdominal scute using the method described by Sexton (1959). Each was permanently marked by notching the marginal scutes using the coding system of Cagle (1939). Sex was determined using the characters (males have a brown iris, brown chin, concave plastron and the cloaca extends past rear margin of carapace, whereas, females have a orange iris, orange chin, flat/convex plastron and the cloaca stops before the rear margin of the carapace) described by Ernst and Barbour (1989). Abnormalities, injuries and numbers of spots were recorded on outline diagrams of the carapace and plastron. All turtles were released within 24 hours at their capture site. Differences in growth between the sexes were tested by a two-tailed independent sample T-test ($P = 0.05$).

RESULTS

ACTIVITY CYCLE

During 1992, water levels were moderately high in early May, and progressively decreased as summer temperatures increased. Much of the site was dry through the summer until rains returned in September. Water depth at the monitoring station fluctuated from 0 to 20 cm throughout the summer, and never was completely dry for a period greater than 24 hours.

The radio-tagged turtles were seen actively moving on land or in water in all months except for February, and November. Other spotted turtles were collected in all months but January, February, November, and December. Peak activity was from April through June (Fig. 1). Lockport spotted turtles became inactive (aestivated) from late June to early July when water temperatures approached 32 C. Aestivation or short periods of activity occurred throughout September to late November. Finally, in late November to early December spotted turtles began brumation which continued until the following spring. All *Clemmys guttata* observed brumating were located in the cattail marsh (Fig. 2).

MICROHABITAT SELECTION

The total study area was 45 ha. This number excludes the northern one half of the preserve and unusable habitat to the turtles (e.g. roads, railroad right of ways, bridges, etc.) agrees with Schiavi (1993). The predominant habitat types were cattail marsh and successional-cultural occupying 29.3 percent and 25.5

percent, respectively (Tab. 1 and Fig. 2).

Spotted turtles often shifted microhabitats daily and seasonally. The eight radio-tagged spotted turtles typically selected sedge meadow and cattail marsh for aestivation (100%), cattail marsh for summer activity/brumation (100%) and fens or dolomite/sedge meadows for nesting (100%) (See Tab. 2 for individual percent captures in a selected microhabitat).

Preference indices that included the entire study area showed that cattail marsh (PI=0.65), sedge meadow (PI=0.64), and wet mesic dolomite prairie (PI=0.41) were the microhabitats most preferred (Tab. 3). Preference indices for home ranges revealed that spotted turtles tended to select cattail marsh (PI=0.69), and sedge meadow (PI=0.58) most often among the available habitat (Tab. 4). Mesic and wet mesic dolomite prairie were equally preferred for the study site and individual home ranges (PI=0.35, and PI=0.31) (Tab. 4). Dry dolomite prairie and floodplain forest were never chosen either in the study site or home range (PI=0.00). Graminoid fen possibly appeared to be preferred by young turtles whereas adults showed a low preference for this microhabitat for both the study site (PI=0.11) and home range (PI=0.12). However, all ages were known to utilize cattail marsh and sedge meadow.

Chi square tests were run for each turtles usage of microhabitat within the home range and study site. Then all turtles were pooled together to get a composite chi square for the study site. All chi square tests rejected the null hypothesis (P=0.05, critical value 0.0, chi-square calculated value 376.6205) indicating that spotted turtles do not choose microhabitats randomly. Selection is based on a individualized preference.

POPULATION ESTIMATION

A total of 98 different turtles have been captured since the initial 1988 survey. The size of the Lockport *Clemmys guttata* population was estimated by using the Schnabel method. Using collected data from 1988 the population was calculated to be 58 turtles by the Schnabel method. Estimates of population for 1990 increased to 105 turtles. In 1991 the estimate was determined to be 137 turtles. The estimate for the 1992 sample was estimated to be 118 turtles. Finally the population size for the spring of 1993 was calculated to be 115 turtles. Population densities for the Lockport site were based on the total number of turtles per hectare for the following: 1) total number of turtles actually collected, 98 turtles/45 ha = 2.2 turtles per hectare, and 2) Schnabel method, 115 turtles/45 ha = 2.55 turtles per hectare.

HOME RANGE

The eight adult turtles that were radio-tracked were relocated between 30 and 64 times (mean = 53.9). Individual home ranges were plotted and digitized (Fig. 3-10) and the areas calculated (Tab. 5). The average home range was 1.36 ha (n=8, and DF=7).

Home ranges and core areas of the spotted turtles studied overlapped in both space and time. Core areas were selected on a seasonal basis but were never as large as their individual home range. Sizes for core areas ranged from 0.007 to

0.30 ha and were significantly different from the total home range (alpha=0.05) (Tab. 6). Males showed frequent overlap of both home range and core areas with females but no overlap with other radio males. Home ranges of females overlapped for both home ranges and core areas of radio-tagged individuals, of both sexes.

Females ranged over a greater area on average than males (1.75 and 0.72 hectares, respectively) a statistically significant difference ($P < 0.05$, two-tail independent sample T-test, DF= 4). However, the average size of female home ranges excluding nest sites was 1.37 ha. which was not significantly different in size when nesting events were included ($P < 0.05$) (Tab. 7). However, one non-gravid female in this study had the largest home range of all radio-tracked turtles (e.g. turtle # 10L12L, home range 2.49 ha).

THERMAL RELATIONSHIPS

Cloacal temperatures were recorded 242 times from 77 *Clemmys guttata*; of these, 198 were active turtles and 44 were dormant in some form. Active turtles had cloacal temperatures ranging from 8.0-33.0 C (Tab. 8-13). *Clemmys guttata* are very cold hardy and are also capable of withstanding moderately high temperatures during periods of aestivation.

Clemmys guttata basked during the daylight hours on warm sunny days throughout the activity season. Table 8 presents temperature relationships for 77 basking turtles. Turtles generally moved to water or shaded areas before cloacal temperatures reached 33.0 C. The environmental temperatures recorded while turtles basked were similar to cloacal temperature (Tab. 8). Correlation coefficients (r) suggest that cloacal temperatures of basking spotted turtles are positively more closely related to water (r=.64), than to the air (r=.59) or substrate (r=.56) temperatures.

Aestivation occurs from July to early September during periods of high temperature and drought. *Clemmys guttata* retreated from the extreme heat of summer by seeking out microhabitats with cooler temperatures. Aestivation on land was observed in shaded areas near *Carex* and *Typha* species for seven of the eight radio turtles. Correlation coefficients for cloacal temperatures of aestivating turtles with environmental temperatures were substratum (r=0.96), air (r=0.81) and water (r=0.25) (Tab. 9).

Dormancy also took place in water both during summer and winter months (Tab. 10-11). Common aquatic aestivation sites at Lockport were muskrat lodges and tunnels. However, aquatic aestivation sites were less frequently found than terrestrial sites (Tab. 9-11). In low temperature water (< 14.5 C), cloacal temperatures of dormant turtles most closely approximated that of the water temperatures (r=.98) as opposed to air temperatures (r=.69). In high temperature water (> 14.5 C), cloacal temperatures closely approximated both air (r=.98) and water (r=.97) temperatures.

Temperatures of moving turtles (not engaged in some specific activity) were divided into two groups: 1) moving on land, and 2) moving in water. Correlation coefficients obtained for those moving in water were substrate (r=0.99), water (r=.96) and air (r=0.74) temperatures (Tab. 12). Temperature correlation coefficients for those moving on land were air (r=.93), water (r=.71) and substrate (r=.88) (Tab. 13).

Data collected for foraging were so few (n=2) that no regression equations were calculated for this behavior. However, descriptive statistics are as follows: mean cloacal temperature=23.3 C, (SD=3.54) with a range of 20.8-25.8 C; mean air temperature=21.9 C, (SD=2.40) ranging from 20.2-20.6 C; mean water temperature=21.1 C, (SD=7.21) with temperatures ranging from 16.0-26.2 C.

REPRODUCTION

Courtship and mating were observed in the morning and afternoon on 20 and 21 May 1992, and 26 March 1993. Those on the 20th and 21st of May 1992 involved one radio-tagged male, and three radio females in a laboratory holding tank. The male was biting at the neck of a female forcing her to pull in, so that a forced copulation could occur (Ernst, 1970b). Tails were in cloacal apposition, but no penetration was observed. The copulatory event that was observed the following year also occurred with the same male. This mating was observed at a water temperature of 6.0 C, and cloacal temperatures for the female and male were 10.8 C and 16.0 C, respectively. These cloacal temperatures suggest that both turtles may have been basking prior to mating. Air temperature for this mating observation was 8.8 C. Mating took place at 1100 h in shallow water adjacent to land. The male mounted the female and their tails were in cloacal apposition; however, his penis was not observed. The male was fully exposed, and out of the water, while the female was partially submerged with her head above water.

Five gravid females (4 of which where radio-tagged) were X-rayed to examine clutch size and egg size (Fig. 11). These females ranged in age from 8-13 years (mean= 11.2) and had plastral lengths ranging from 89.3-104.0 mm (mean= 98.44). The five clutches totaled 20 eggs, ranging from 3 to 5 (mean= 4.00). To undergo nesting in natural habitats females were then released at their capture site.

Nesting of the radio-tagged females occurred from 18 June 1992 to 26 June 1992 between dusk and dawn. Females emerged from the marsh in late afternoon to early evening. Those encountered from 1800-2000 h had made their nest site selection. Once a nest site was selected females remained there until the nesting attempt was completed.

During nesting, females supported their body with their front limbs; hind feet were used alternately for digging, while other feet acted as a tripod brace. The dirt was scooped out by cupping the hind foot and females continued to dig even after they could go no deeper. All eggs were deposited in one flask shaped nest (no multiple nestings were observed). After oviposition, the female shifted her plastron from side to side, up and down on the substrate. This aided in packing down and creating a hard nest plug (Ernst 1970b). Approximately 12 hours were needed for nesting, from the beginning of excavation through packing down of the nest.

Nesting turtles remained at their nest sites until nesting was completed, unless molested by a predator or certain physiological factors interfered with their nesting. One female (3L8R) encountered physiological difficultly while nesting. This female made three nesting attempts, digging and abandoning these cavities from 18 June 1992 to 26 June 1992. An injection of oxytocin was administered on 30 June 1992 and approximately 3 hours later, eggs were laid in the laboratory, and this female was released on 1 July 1992. Later the same day, she was observed less than 1 m from a newly dug nest hole. This nesting attempt could have been a side effect of the oxytocin hormone. Indicated by the fresh dirt on the females's hind limbs and rear portion of her carapace.

Before oviposition, the dimensions of 20 eggs were measured from X-ray photography. Eggs ranged in size from 14-19.5 mm width and 27-36 mm length (mean= 17.7 mm X 31.4 mm). All eggs were elliptical and white with slightly pliant shells and neither having a typical soft leathery shell nor a hard brittle shell. The egg shell may be best categorized as "hard-expansible", a term coined by Ewert (1979). Eggs in the laboratory clutch became more turgid as incubation progressed.

The three clutches laid in the field were protected by hardware cloth enclosures, but all were destroyed by flooding caused by heavy rains. As for the single clutch laid in the laboratory, two eggs hatched after a 91 day incubation period (6-30-92 to 10-1-92). The remaining 2 eggs did not hatch but had fully developed embryos which experienced prehatching mortality. The hatching success of the laboratory clutch was 50 percent. The success of the non-radio female's clutch was unknown. Compiled survivorship percentages for both the field and laboratory clutches showed that 13 of the 15 eggs from radio-tagged female's did not survive. Hatching success was 13.3 percent, and prenatal mortality was 86.6 percent. The realized reproductive potential, assuming an average sized clutch (mean= 4 eggs/clutch), at the Lockport site was 0.54 young/clutch. Of the 4 females radio-tracked, no evidence suggests more than one clutch per season.

GROWTH

Growth varied individually depending on the availability of resources and environmental factors (such as temperatures and rainfall). Growth rate is highest in the first few years and levels off markedly at age 7 when the turtles are approximately 80 mm (Fig. 12-13). Males increased 22.17 percent in plastron length for their first year whereas females increased 21.4 percent (Tab. 14). Growth gradually decreased for both sexes as age increased. Percent increase was very low by age 11 (males 0.0% and females 4.94%).

Males and females (Fig. 13) showed similar growth curves. However, there were significant size differences for age classes 2-6. In all cases showing a size difference, males were significantly larger than females ($P<0.05$), two-tailed independent sample T-Test with degrees of freedom for each age class (in parentheses) are as follows: DF= 14(0), 21(1-6), 18(7), 15(8), 12(9), 4(10) (See Fig. 12 and 13).

Six others turtles collected during their first year of growth had plastron lengths ranging from 22.5 to 44.5 mm. Three of these had calculated plastral lengths at hatching that were less than 22.5 mm PL (range 19.13-22.5). As the dates of capture were too early for much growth to have occurred during the current activity season, it appeared these turtles must have hatched the previous year and added this growth prior to winter dormancy.

The majority of *Clemmys guttata* showed subannuli indicating cessation of growth during the growing season and are probably formed during periods of aestivation or other temporary unfavorable weather conditions.

SHELL ABNORMALITIES

Shell abnormalities were recorded for 63 of 98 individuals (64.28%), 27 (27.55%) adult males, 27 (27.55%) adult females and 9 juveniles (9.18%). Most abnormalities involved shell pitting which occurred on both the carapace and plastron. Pitting was found in 28 individuals (28.57%) including 12 (12.24%) males, 10 (10.20%) females, and 6 (6.12%) juveniles.

Other abnormalities included supernumerary scutes, and plastral erosion or cracking. Only two males and three females exhibited abnormalities involving plastral cracks and/or erosion of the plastral bridge. Fourteen turtles had supernumerary scute deformities (addition or division of scutes) including 6 (6.12%) males, 7 (7.14%) females, and one (1.02%) juvenile. Vertebral scutes were most variable with 4 abnormalities; one individual had vertebral number one bisected whereas three others had eight, ten, and twelve vertebral scutes arranged in a zig-zag fashion down the back. Supernumerary scutes are those that are broken down into smaller parts of the normal scute. Supernumerary scutes were recorded and described below, along with the number of cases in parenthesis: humeral (1), pleural 4L (1), right pectoral and humeral (1), left abdominal (1), left abdominal/femoral (1), 1R pleural (1), left abdominal (1), left and right anal/femoral (2), left and right abdominal/femoral (1), 1L pleural and 1st vertebral (1), 1R pleural, 1st vertebral and 1R marginal (1), and three individuals had thirteen marginals on either the right or left side.

Besides subdividing of scutes, other deformities involved serrating or notching of the marginal scutes. Sixteen individuals had serrated or notched marginal scutes including 7 (7.14%) males, 7 (7.14%) females and 2 (2.04 %) juveniles. Those variations were not observed in hatchlings.

I observed 12 individuals that had noticeable burn scars which occurred primarily on the carapace. Lockport prairie is burned approximately once every two years either in the fall or spring of the year. Unfortunately some turtles may be lost because of this process, but most seem to cope with this prairie restoration/management technique. In the 1992 study, 88 turtles were recaptured out of the total 98 turtles recorded, this possibly suggests that 10 turtles have been lost to fire. However, most of the scarred animals have healed with no apparent permanent harm done to the animals.

FORAGING

I observed a male spotted turtle feeding on land, consuming an adult dragonfly on 7 July 1992 at 1517 h in a monotypic cattail marsh. The recorded air temperature was 26.0 C with a substrate temperature of 20.0 C, and water was scattered throughout the area in puddles.

PREDATION AND ANTI-PREDATOR DEFENSE MECHANISMS

Few turtles collected alive showed signs of predator attacks or injuries. Two males suffered tail injuries that were described as either a stump/bobtails or crimped 90 degrees ventrad. One female had suffered a flesh wound to the hind right extremity. Another female apparently was attacked or disturbed by a raccoon (*Procyon lotor*) during a nesting attempt, but no apparent damage was done to the female. The female had moved approximately 2 m from the nest site and upon my arrival was trying to reorient towards the water. The nest site had signs of disturbance indicated by the fresh tracks of a raccoon (*Procyon lotor*). Spotted turtles are frequently known to brumate in or around muskrat tunnels or lodges. Two males had apparent gnaw marks on their carapace, presumably by muskrats. One male in particular had suffered severe carapacial damage, where approximately the rear 20 percent of the carapace was removed by such gnawing.

Spotted turtles have few mechanisms to deter predators other than concealment and their ability to retract the head and limbs into the shell. Two males had extended their penis after being picked up. Similar behavior has been observed in snapping turtles at the site, but it is unclear how this would deter a predator. In certain turtles the penis is used to push feces out of the cloaca (Moll, et al. 1987) which may be a deterrent but no feces were expelled during these observations.

SOCIALITY

Clemmys guttata are usually solitary. On some occasions they will share the same areas during inclement weather. No mating aggregations were observed such as those described by Ernst (1967). According to Ernst (1976) this species is not known to be territorial. On 10 October 1992 at 1520 h the resident male was located in his core area mounted on a intruding male which was submerged. This observation could be interpreted as a territorial encounter. The radio-tagged male (resident male) had a cloacal temperature of 12.4 C with water and air temperatures of 12.6 C and 17.0 C, respectively. By 1530 h the resident male and the intruding male were back together in a faced off stance. The resident male turned to leave the area with the intruding male pursuing directly behind the resident male. In the following days the resident avoided his previously utilized core area (territory) moving west and then southward (in a "C" configuration), and never returning to that area.

DISCUSSION

DISTRIBUTION

Authors such as Cahn (1937) and Mauger (1988) suggested that the spotted turtle is directly linked to cattail marshes. Mauger (1988) proposed that it is probable that spotted turtles occur in extreme northern Illinois and southern Wisconsin where cattail marshes exist. It is known to be true that spotted turtles frequent cattail marshes throughout their range.

Spotted turtles (*Clemmys guttata*) have been reported in Wisconsin by Higley (1889). However, Vogt (1981) stated that this species does not belong on the Wisconsin reptile and amphibian list. Early reports of spotted turtles may have been misidentified Blanding's turtles, (*Emydoidea blandingi*). The only Wisconsin *Clemmys guttata* specimen is one neural bone that was part of a necklace discovered at an Indian archeological site. Native Americans frequently walked great distances and traded items such as jewelry made of tortoise shell (Vogt, 1981).

There are no records of spotted turtles from extreme northern Illinois (Smith, 1961). Minton (1972) claimed that spotted turtles formerly occurred in the Chicagoland area. Despite extensive searches, I have not found this species in extreme northern Illinois or southern Wisconsin. However, Blanding's turtles are semi-aquatic and were observed in similar habitats. Smith (1957) states that *Clemmys guttata* does not occur in Wisconsin due to the boreal nature of the climate. I suspect that the key habitat component at the western range limit is a combination of cattail marsh and sedge meadow microhabitats in juxtaposition.

ACTIVITY CYCLE

Clemmys guttata are primarily diurnal in their habits. Other than nesting females, turtles were not encountered on land at night, and only a few captures occurred in water (submerged and buried in substrate). Ernst (1976) suggested that this activity cycle evolved for predator avoidance. The probability of predation when buried in the substrate of a body of water is low. Also there may be advantages to nesting in the daytime, possibly to avoid nocturnal predators; however, high daytime temperatures may preclude such strenuous activity.

Periods of basking and other daily activities varied with weather conditions. Ernst (1976) stated that *C. guttata* shifted daily activity patterns from afternoon peak activity in March to morning peak activity later in the summer. *Clemmys guttata* are capable of tolerating moderately high temperatures, with a critical thermal maximum of 41.98 C (Hutchison, et al., 1966). However, they retreat to the water or shade as they approach their mean preferred temperature (21.1-24.9) (Graham and Hutchison, 1979). This phenomenon of decreasing periods of activity is correlated with a daily rise in ambient temperatures. Graham and Hutchison (1979) stated that the mean preferred temperatures in *Clemmys guttata* correlate inversely with increases in daylength.

The annual activity cycle of *Clemmys guttata* appears to be related to environmental temperatures, which in turn influences reproduction, feeding, nesting, and aestivation. Ernst (1976) stated that the water temperature is the limiting factor controlling activities of spotted turtles throughout the year. This was also observed for the Illinois population.

A measure of seasonal activity in turtles is their frequency of first time captures. The frequency of first time captures of active *C. guttata* is highest after spring emergence in March and decreases markedly as the year progresses (Fig. 1). These findings agree with Conant (1951) for Ohio, Nemuras (1966) for Maryland, Ernst (1976) for Pennsylvania, and Ward et al. (1976) for Maryland. After emergence, mating begins immediately and continues through May. In late June and early July turtles become much more difficult to capture as water levels drop and summer temperatures rise. The Illinois spotted turtles annual activity cycle could best be described as spring emergence (March to April), active in spring to early summer (April to June), aestivation occurs in late summer to early fall (July to September), turtles are active for shorter periods in the fall to early winter (September to November) and by December brumation has already begun.

Ernst's (1976) Pennsylvanian population of *C. guttata* have a slightly different annual activity cycle. Spotted turtles became inactive as water temperatures approached 32 C. The majority of turtles remain inactive until they emerge the following spring. A few individuals are seen during the cooler days of summer, fall, and in the warmer days of winter. Netting (1936) found a spotted turtle migrating from a terrestrial woodland to a swamp. He suggested that the hibernaculum was in the woods and the turtle was "homing" toward the swamp to initiate spring activity. Even though a woodland microhabitat exists at Lockport, no *C. guttata* were found brumating in any microhabitat other than cattail marsh.

The average air temperature recorded for aestivating spotted turtles at Lockport was 24.2 C (Tab. 9). This agrees with findings reported by Ernst (1982) that *C. guttata* begin aestivation at air temperatures of 22.61 C. Lovich (1988) also reported that frequency of capture throughout the spotted turtle range declines when the mean normal air temperatures first exceeded 22.61 C. Even though favorable temperatures may return later in the season, most of these turtles remain inactive until the following spring. Ward et al. (1976) suggested that the inactivity is largely due to decreased food supply during this period.

MICROHABITAT SELECTION

Habitat selection in *Clemmys guttata* has received some interest over the years by such researchers as Ernst (1976; 1982) and Ward et al. (1976). Microhabitats selected by this species appear to be associated with their activity cycles, including nesting, foraging, aestivation, brumation, and mating/courtship (Ernst, 1970a, 1975, 1976, 1982; Ward et al. 1976). Minton (1972) stated that their habitat in Indiana is shallow water with undisturbed meadow or undergrowth. Where marshland is surrounded by successional-cultural habitat the spotted turtles disappear; however, little attention has been given to microhabitat preference. Herein selection and preference are not assumed to be the same. A selection shows use of a microhabitat, whereas preference relates use to availability. Previous studies have marked and recaptured turtles and recorded seasonal microhabitat selections. However, no researchers have stated what microhabitats *Clemmys guttata* prefer. In this study, preference indices were determined for spotted turtles in microhabitats available within the entire study site and within each home range (Tab. 3 and 4).

Cattail marsh and sedge meadow were equally preferred by turtles over the entire study site (PI=0.64 and 0.65) as well as in their individual home ranges (PI=0.69 and 0.58) (Tab. 3 and 4). These findings were similar to those of Ernst (1976) and Ward et al. (1976). Spotted turtles frequently inhabit bogs, marshy pastures, and woodland streams (Ernst and Barbour, 1989). Lockport is a typical semi-aquatic habitat. It contains neither bogs nor woodland streams; however, it does have cattail marshes and sedge meadows. Cattail marshes surrounded by sedge meadows create a combination which emulates the marshy pasture (meadow) described by Ernst and Barbour (1989). The edge effect between cattail marsh and sedge meadow microhabitats enhance the desirability of these two microhabitats.

Graminoid fen was one of the lowest preferred microhabitats for both the study site (PI=0.11) and home range (PI=0.12). However, other researchers frequently encountered hatchlings and young juveniles at Lockport in the graminoid fen, and thus coined it the "nursery". Fens are highly vegetated with bulrushes (DeMauro, 1986) that provide fairly good cover for hatchlings against predators. These fens have water levels that are shallow and sunlight is allowed to penetrate in open areas where basking may occur. With shallow waters, rich food source and ample cover, fens make one of the better areas to find younger individuals (Mauger, 1990).

Floodplain forest and successional-cultural microhabitats were two of the least frequently chosen microhabitats for both the study site and home range with PI values (0 and 0.01) and (0 and 0.21), respectively (Tab. 3 and 4). The lower preference values of the floodplain forest maybe attributable to the dense vegetation creating a "canopy" that eliminates suitable basking sites. The successional-cultural microhabitat has suffered a great deal of abuse in the past and is only starting to recover. Most of the native plants are absent and water and ground cover are lacking. Even though spotted turtles are semi-aquatic, they do require water and hiding places (i.e. for thermoregulation, aestivation, and foraging). The only observations of spotted turtles in the successional-cultural microhabitat were transient movements across open expanses of land.

Dolomite prairie microhabitats (numbered 1-5) have preference indices ranging from 0.0 - 0.41, which are relatively low when compared to the PI of cattail marsh and sedge meadow microhabitats. Dolomite prairies are rare communities in Illinois. Lockport contains the highest percentage of this prairie type in Illinois (DeMauro, 1986 and Schiavi, 1993). Dry dolomite prairies are more susceptible to disturbance when compared to wet dolomite prairies. Lockport Prairie Nature Preserve was dedicated in 1983, and it is unlikely that these habitats have had time to recover from farming, grazing, and heavy all-terrain vehicle usage. Since dry dolomite prairie and dry mesic dolomite prairie are most sensitive to disturbance, they occupy only a small percentage of the study site, 0.65 percent and 5.77 percent, respectively. The low percent of occurrence and a uneven distribution may explain why these microhabitats have a low PI value. (Tab. 3 and 4). Possibly as the land recovers, the spotted turtles' preference for dry dolomite and dry mesic dolomite prairie will increase. At this time dry dolomite prairie and dry mesic dolomite prairie are not primary habitat components for spotted turtles. Wet mesic dolomite prairie is the most preferred of the dolomite prairie types present at Lockport (Tab. 3).

In combination with the PI values and Chi square tests which indicate that habitat selection is not random, cattail marsh with associated sedge meadow appear to be the preferred albeit "critical habitat" for this turtle in Illinois.

POPULATION ESTIMATION

The population of spotted turtles in Will Co. is fairly small when compared to the area of the site. Nonetheless, the turtles are reproductively active, with what appears to be low nest survival rate. A combination of a low nest success and a closed (?) population could, in a matter of years, drastically reduce the population size of the spotted turtles at Lockport.

The capture-recapture data from the years from 1988 to 1993 gives us a fairly close estimate of the marked population at Lockport. The capture record has 98 different turtles recorded since the 1988 survey, and the proposed estimate of 115 turtles by Schnabel method closely resembles this number. It is unknown if recruitment rate is high enough to offset mortality rate. This is where problems could be encountered due to using the Schnabel method, this method does not account for birth and death rate. The Schnabel method assumes a closed population and I believe Lockport is in fact more of a closed population with no emigration or immigration. However, further population studies should be conducted using the Jolly-Seber method. The guide lines for the Jolly-Seber method should be accurately followed using the methods employed by Jolly (1965), and Seber (1965). Only then can one confirm the population estimates at Lockport.

HOME RANGE

Lockport spotted turtle home ranges (mean= 1.36 ha) are significantly larger than the 0.53 hectares reported for a Pennsylvania population (Tab. 5 and see Ernst, 1970a). This difference may be an artifact of differing definitions of home range and techniques used for locating turtles. Ernst followed Legler (1960) by excluding transient and nesting movements in his home range calculation. I believe that all data points should be included in home ranges after Burt (1940). However, even when nesting movements were excluded, the average home range (1.13 ha) for all turtles was not significantly different than the average home range when nesting movements were included. Biotelemetry was used to track turtle movements at Lockport, whereas Ernst (1970a) used only hand capture methods. The former being more efficient, it may have increased the number of points outside the core area(s); therefore, larger home ranges exist at Lockport.

It was noteworthy to illustrate overlap in home ranges and core areas of the

Lockport turtles (Fig. 2). Ewer (1968) stated that vertebrate home ranges commonly overlap, and core areas do not. This appears to be true in spotted turtles; however, core areas of females, overlapped with both sexes whereas males overlapped frequently with females, but less frequently with other males. There was seasonal shifting of core areas/individual activity centers, apparently due to biotic causes. In this study, core areas were significantly smaller than home range areas (Tab. 5 and 6). Core areas for most vertebrates are presumed to be closely related to home range size and differ seasonally (Clutton-Brock et al., 1982). This disagrees with my findings; however, core areas were not found to be of similar size when compared to home range.

The home range differences may not be due to technique or definition, other explanations include lower population density and a more carnivorous diet in the Illinois populations. The Lockport population density of 2.2 turtles per hectare was considerably lower than the population density of the Pennsylvania population (12.25 turtles per hectare; Ernst, 1970a). Home range sizes are frequently inversely correlated with population density (Schoener, 1981). If this applies to turtles, then individuals in the less dense population would be expected to produce larger home ranges.

Carnivores tend to have larger home ranges than herbivores (Rowe, 1987; McGee, 1988). Capler and Moll (1988) found diets of Lockport spotted turtles to primarily consist of animal material (76.8% animal, 23.2% plant). Whether Lockport turtles tend to be more carnivorous than Ernst's spotted turtles is not known because Ernst (1976) stated that Pennsylvania spotted turtles are omnivorous and that both plant and animal materials are consumed. If Lockport turtles are more carnivorous, then this may be another factor explaining the home range difference in the two populations. A final hypothesis in home range difference could be that conditions at the periphery of this turtle's range are less optimum than in Pennsylvania, requiring that the turtles must range over a larger area which allows them to find adequate biotic/abiotic resources.

THERMAL RELATIONSHIPS

Biophysical temperatures were taken for eight representative behaviors (Tab. 8-13). The lowest cloacal temperature recorded for active turtles at this study site was 4.4 C. Ernst (1967, and 1982) observed *C. guttata* active in water at cloacal temperatures of 3.0 C. These temperatures attained are equal to or below the minimum voluntary temperatures of 8.3 C (Brattstrom, 1965). Graham and Hutchinson (1979) in their laboratory experiments determined *C. guttata* had a mean preferred body temperature of 23.8 C (17.3-29.1) for 15-25 C (water temperature) at a photoperiod of 8 hr light: 16 hr dark. Hutchinson et.al., (1966) determined that the critical thermal maximum for *C. guttata* to be 41.98 C (41.2-42.5). Spotted turtles observed at Lockport never approached their critical thermal maximum temperature. Because cloacal temperatures never exceeded 33.0 C in this study (Tab. 8-13). Spotted turtles generally are unseen during the hotter hours of the day when the chance of reaching their critical thermal maximum is increased.

Generally, cloacal temperatures of ectotherms tend to correlate best with the medium in which they are most closely associated (Brattstrom, 1965 and Boyer, 1965). For example, turtles moving in water would be expected to have cloacal temperatures most similar to the water temperature. Similarly, aestivating turtles buried in the substrate should be similar in temperature to the substrate temperature. While this was usually true in this study, a couple of exceptions are discussed below.

Correlation coefficients recorded for cloacal temperatures of basking turtles in this study (air $r=0.59$, water $r=0.64$, and substrate $r=0.56$) are considerably lower than those of Ernst's 1982 study (air $r=0.81$, water $r=0.81$, and substrate $r=0.89$). Possibly the lower "r" values in this study are attributable to different emergence times between the turtles among the two populations. Ernst noted that a higher correlation resulted when the substrate color matched the dark coloration of the turtle's carapace. At Lockport the soil was typically much lighter than the turtles shell. This could explain the low correlation between turtle and substrate temperature, but not that of the air and water. The higher correlation with water temperature would be explainable if a high percentage of the turtles had recently left the water.

Cloacal temperatures of turtles moving in water correlated higher with the substrate temperature ($r=0.99$) than with the water ($r=0.96$) but the sample size was limited to three. Similarly temperature of turtles undergoing summer dormancy in water showed a slightly higher correlation with air temperature (r=0.98) than with the water (r=0.97) but sample sizes were 3 and 4, respectively.

REPRODUCTION

Courtship and mating activities typically occur from March to May. The timing of these activities at the Lockport site showed little deviation from those in Pennsylvania (Ernst, 1975). Nesting began in late June or early July each year. Factors controlling nesting are not known. In a similar species, *Emydoidea blandingi*, nesting has been correlated to temperature. Apparently, several warm days in April are needed to stimulate vitellogenesis in females (Congdon et al., 1983). If Blanding's turtles and spotted turtles have similar factors initiating their reproductive cycles, one could speculate that since Blanding's turtles nest approximately one month earlier than *C. guttata*, critical temperatures for vitellogenesis of spotted turtles must occur some time in late April to May.

Nocturnal nesting of *C. guttata* has also been shown by Ernst (1970b; 1976) despite the fact that this is a time of increased mammalian predator activity. The small size of adult female turtles makes them vulnerable to predation. No predation mortality of nesting spotted turtles is known from this study, although encounters with predators likely occurred. Raccoons (*Procyon lotor*) are the most common of the potential nocturnal predators in the area. Observations of predation by raccoons were noted by Ernst (1976), Nemuras (1966) and Grant (1935).

Emydoidea blandingi are large semi-aquatic turtles that nest nocturnally and occasionally inhabit the same areas as spotted turtles (Congdon et al., 1983).

Their larger size and hinged plastron lowers their risk of predation. A smaller species that inhabits the site with spotted turtles are painted turtles (*Chrysemys picta*). Both spotted turtles and painted turtles are significantly smaller than the Blanding's turtles, which makes them more vulnerable to predators. However, *C. picta* nest diurnally when predator activity is low (Tinkle et al., 1981). All spotted turtle nestings took place at night. There must be some other factor that balances out predation risk for the spotted turtle.

Clemmys guttata prefer cool temperatures and are more prone to desiccation, compared to other freshwater turtles (Ernst, 1968). Hence they nest at night when evaporative water losses are decreased. Alternatively, spotted turtles could heat up rather quickly because of their small size and black carapace. If they were to nest in the day time, the combination of heat generated from muscular movements and heat absorbed by the black shell may push body temperatures to their critical thermal maximum (Hutchison, 1979). In either case the proximate factor is physiologically based, therefore, spotted turtles have nocturnal nesting habits.

Generally, egg sizes are similar to those reported from other localities (Babcock, 1919; Carr, 1952; and Ernst 1970b). However, the hard expansible egg shell type found at the Lockport site has never been reported before in other populations of spotted turtle.

The incubation period of 91 days from the laboratory hatched clutch is longer than the mean (76d) and range (70-83d) found by Ernst (1970b). However, the laboratory conditions were likely different from those of natural nests.

All field nests at the Lockport site failed. Iverson (1991) states that a study conducted by Ernst for a Pennsylvania population has an egg to hatchling survivorship rate of 58 percent. My results may be lower due to the small sample size (n=11) and flooding at the site in 1992. Lack of well drained nesting habitat may decrease survivorship of eggs at Lockport.

GROWTH

Chelonian growth is influenced by such factors as temperature, rainfall and resource competition (which is primarily food-related). *Clemmys guttata* grow fairly rapidly when young, but growth rates of the spotted turtles for Lockport differ from eastern populations. Turtles at Lockport increased in size 21.8 percent in their first year, then growth rates slowly decline to 2.47 percent by their tenth year (Tab. 14). These growth rates are slower than those reported by Graham (1970) and Ernst (1975). They had reported size increases for the first year of 42.98 percent and 46.65 percent, respectively. For individuals over 10 years old, Graham and Ernst reported growth rates of 8.08 percent and 2-3 percent, respectively. My results differ from both studies in the early years of turtle growth, and continue to differ from the study conducted by Graham (1970). However, older turtles (10+ years) show similar growth rates as compared to adult turtles from a Pennsylvania population (2-3% growth rate) studied by Ernst (1975). The differences between the Lockport and the eastern populations could be enhanced by the fact that the Lockport turtles are larger in size at each age class when compared to other populations. Plastral growth slows gradually compared to other aquatic emydids such as *Chrysemys picta* or *Trachemys scripta* which often have growth curves that rise sharply then drop off abruptly (Gibbons, 1968; Moll and Legler, 1971). The slower growth rate and the older age at maturity reflect the shorter activity season of the spotted turtle (Ernst and Zug, 1994).

Growth studies on the spotted turtles are few and no growth studies have been completed in Illinois. My data suggest that spotted turtle growth begins to slow at sexual maturity (approximately age 7) (Fig. 13). Ernst (1970; 1975) states that growth begins to level off at about 7-10 years (or 80 mm plastron length) when sexual maturity is reached. Graham (1970), conducted a growth study on spotted turtles in Rhode Island, and reported age 8 as the year of sexual maturity.

Males at the Lockport site were found to be significantly larger than females. Size differences were found at most ages under seven (except for 0, 1, and 7). At Lockport, male and female hatchlings are not significantly different in size. As time progressed, males surpassed females in size. Two possible explanations are that males out compete females at exploiting food resources, or perhaps females must put more resources into development of gonads sooner. Lovich (1990) suggested that male spotted turtles are more apt to move during the spring of the year as compared to females, which are more loyal to core areas. He proposed that males are potentially able to cover more ground and thus enhance their probability of acquiring resources. These finding disagree with the movement patterns found in this study; where females cover more ground and are still significantly smaller than males.

Johnson (1989) reported comparable size ranges of adults, but gave no sexual size differences in spotted turtles. Size differences between sexes have been shown for other species of *Clemmys*. Ernst (1977) states that female Bog turtles, *Clemmys muhlenbergii*, are smaller as hatchlings and remain smaller throughout life. Further research needs to be conducted in this area for emydid turtles. This study could further be strengthened by having larger sample sizes for each age class.

SHELL ABNORMALITIES

The phenomenon of morphological shell abnormalities cannot be analyzed by one technique, instead several methods should be employed, such as paleontology, evolution, developmental biology, comparative anatomy, genetics and other biophysical techniques. My research focused on collecting the types and numbers of abnormalities among the age classes (hatchling, juvenile and adult), with brief descriptions. Sixty-three individuals were recorded with shell abnormalities. Newman (1906) suggested that shell abnormalities have an evolutionary origin. Primitive turtles had a greater number of scutes; thus supernumerary scutes in modern turtles may be a "throw back" to the primitive state.

Lockport turtles have a higher frequency of abnormalities in adults, but no abnormalities were found in hatchlings. Zangerl and Johnson (1957) and Ernst (1976) also noted a higher frequency of abnormalities in adult versus juvenile stages. Ernst recorded 25 individuals with shell abnormalities in a Pennsylvania population. The percentages of shell abnormalities obtained at Lockport (64.28%) are considerably higher than those found in Pennsylvania (5.3%). Ernst (1976) found no abnormalities in hatchlings and proposed that some shell abnormalities are caused by winter dormancy where freezing of growing tissue may occur. However, Costanzo et al., (1993) stated *Terrapene carolina* are able to withstand temperatures less than -3.6 C for several days and freeze greater than 58 percent of its body solid with no apparent damage done to the animal. No data were given on abnormalities in relation to freezing. Perhaps the drying and desiccation experienced during aestivation periods could be a factor in shell abnormalities.

Lockport is located downstream from the Chicago metropolitan area and acts as a water retention unit for excess water. It is also surrounded by heavy industrialization. It is possible that chemical pollution could be a factor in shell deformities. Since no hatchlings were observed with shell deformities and the frequency increases with age, it is possible that such toxins are present and magnified in the food chain creating side effects over time. The lower percentage of shell deformities in the Pennsylvania population may be attributed to lower concentrations of pollutants. This site is a bird sanctuary and is not surrounded by industrialization. The likelihood of high concentrations of toxins is unlikely at this site. The Lockport site has a higher probability of having such toxins, thus higher numbers of deformities are encountered. No toxicology studies were performed at Lockport.

Also another possible hypothesis could be that a greater level of inbreeding exits at the Lockport site, due to the smaller, and more isolated population at the western range limit. Further study is needed to determine the causes(s) of shell abnormalities.

FORAGING

Spotted turtles reportedly feed only in or under water (Ernst, 1976; Carroll, 1991), but my observations suggest otherwise. It is unlikely that the male I discovered consuming an adult dragonfly on land seized this prey item while it was flying past. It is possible that the insect fell into the water or on land and the turtle overpowered it and carried it back for consumption. Based on this observation, spotted turtles are now known to be capable of feeding on land as well as submerged in water. Surface (1908) listed several terrestrial insects as prey items for spotted turtles. These findings suggest that the insect could have been captured on land.

PREDATION AND ANTI-PREDATOR DEFENSE MECHANISMS

Raccoons (*Procyonidae*) and mink (*Mustelidae*) are common predators of smaller species of turtles (Ernst, 1976). Other mortality/injuries may occur when muskrats (*Muridae*) gnaw on brumating turtles which retreat into their tunnels and lodges to escape harsh weather conditions (Grant, 1935; Nemuras, 1966). Such gnaw marks were discovered on the rear margins of two male turtles at the Lockport site. These are probably not predatory attacks by the muskrat, but an inherent desire to clear passage ways (Nemuras, 1966). However, it could also be motivated by a demand for calcium by the rodent.

The most common anti-predator defense mechanism for emydid turtles is to swim away or to retract into the shell and remain motionless. In the batagurid turtles, it is known that when a male is picked up or turned over, simulating a predatory attack, a male will extend his penis and defecate on the predator. These are anti-predator defense mechanisms (Moll, et al., 1987). A similar behavior (extending penis without fecal expulsion) was observed in the Lockport spotted turtle population, but it is unclear how this behavior would deter a predator. Perhaps no feces was available at the time of capture for these spotted turtles to deter a predator.

SOCIALITY

While spotted turtles are typically solitary, males are found associating with females during the mating season. At these times, male spotted turtles are aggressive towards other males if courting females are present (Ernst, 1967). Male aggression was recorded once at the Lockport site in October with no females present. This highly unusual behavior has not been described prior to this study. Harless (1979) concluded that territories probably do not exist in freshwater turtles, but I believe that due to the displacement of the radio male (2R3R) from his activity center, territories may indeed exist in spotted turtles.

FACTORS LIMITING THE RANGE OF THE SPOTTED TURTLE IN ILLINOIS

Comparisons of the Lockport population (at the western limits of the range) with that of a well-studied eastern population in Pennsylvania, reveals several differences.

1) Lockport *Clemmys guttata* show a greater preference for cattail marsh and sedge meadow habitat.

2) The Wisconsin glaciers withdrew from Illinois approximately 8,000 years ago. It is unlikely that this turtle existed in Illinois prior to this time. Suggesting that this species had to migrate after the glaciers retreated and a prairie community evolved. Possibly this turtle was not able to expand its range any further in this amount of time, thus the western part of the range ends in northeastern Illinois.

3) The boreal climate of Wisconsin has been stated to be unfavorable for spotted turtles, but has been known to be productive for Blanding's turtles. Blanding's turtles are known to be abundant in Wisconsin and certain areas of northern Illinois. Whereas, the spotted turtle is most abundant in the eastern parts of the United States and the Blanding's turtle is absent from most of these areas. It is possibly due to competition with Blanding's turtles that the spotted turtles' western range limit ends in Illinois.

4) Lockport females have significantly larger home ranges than males, whereas in Pennsylvania, males and females show no home range size

difference.

5) Lockport spotted turtles have eggs with a hard expansible shell as compared to the more flexible parchment like shell found in the eastern population.

6) Males are significantly larger than females at Lockport, whereas the sexes of the Pennsylvania population did not vary in size.

7) Physical factors such as temperature and moisture could also play a part in the factors controlling the western range limit (in Illinois).

Possibly only the first, second, third and seventh in combination with each other has had any great significance in explaining why the range of the spotted turtle ends in Will Co. Spotted turtles are restricted to the Northeastern Morainal Division of Illinois (Schwegman, 1973); this region consists of soils derived from glacial drift rather than loess. Drainage is poorly developed and many wetland situations, including bogs, fens, and sedge meadows are common. The range of the turtle ends as this division grades into the Grand Prairie Division. This division with its black loess soils and marshes dominated by cattails, but lacking extensive sedge meadows, appears to have been favorable to the Blanding's turtle but not the spotted turtle (Pers. Comm. E. O. Moll, 1994).

MANAGEMENT RECOMMENDATIONS

1) Restoration of natural prairie conditions should be carefully planned to enhance the desirability of unfavorable microhabitats. Microhabitat 10 (successional-cultural) should have sedge grasses or bulrushes planted to

develop this area, and increase usage of this microhabitat.

2) Further study should be conducted on locating and monitoring nests to assess which microhabitats females prefer. From this, we can develop a microhabitat nesting index that can infer what habitats need to be increased to better enhance hatching success and nest survival.

3) Prescribed burning should occur in alternate years from December to February only. It is known that less intense burns occur in the fall of the year. This in combination with burning after the animals have secured a safe hibernaculum, will decrease the numbers of injured and dead animals caused by burning.

4) The Lockport spotted turtle population should be sampled periodically to review population size and age dependent survivorship (via the Jolly-Seber method).

5) Since the site is located in the Des Plaines River flood plain, and originally was used to retain flood waters; careful monitoring and control of water level will help avoid excess flooding at the Lockport site. If flood control does not occur between the Chicago and Lockport lock/dam systems, the spotted turtles reproductive success will be drastically reduced, thus possibly pushing this population to the verge of extinction. However, with careful monitoring of the species, and proper management of the habitat, the population has the potential to survive.

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TABLES (1-14)
LEGEND FOR TABLES (1-4)
CONCERNING MICROHABITATS (1-10)
REFER TO FIGURE 2 OR APPENDIX A

Table 1. Percent areas of microhabitats comprising each turtle's home range. Microhabitat #9 was ommitted due to the fact that it was not in any turtles home range. An "X" indicates that the microhabitat does not occur in a animals home range.

Turtle	1	2	3	4	5	6	7	8	10
3L1R	X	X	2.68	2.72	X	76.7	13.4	4.5	X
2L12L	X	4.8	3.5	11.52	.65	52.3	26.3	X	.93
3L10L	X	3.2	X	17.6	X	47.7	16.3	X	15.2
3L8R	X	9.9	X	1.0	20.8	28.3	40.0	X	X
10L12L	4.4	57.3	10.2	3.42	2.34	12.5	4.17	X	5.7
11R	X	43.5	X	6.83	X	32.4	16.0	X	1.3
1R12R	X	X	X	3.83	15.0	39.7	41.5	X	X
2R3R	X	X	22.0	7.59	X	49.0	21.4	X	X

Table 2. Percent of observed relocations of eight radio-tracked turtles within a given microhabitat (1-10) (X symbolizes microhabitat not in turtles home range; * symbolizes microhabitat present in home range but not utilized).

Turtle	1	2	3	4	5	6	7	8	9	10
3L1R	X	X	6.56	*	X	50.82	40.98	1.64	X	X
2L12L	X	9.09	3.03	3.03	*	60.61	24.24	X	X	*
3L10L	X	*	X	17.46	X	68.25	7.94	X	X	6.4
3L8R	X	1.69	X	5.08	8.47	32.20	52.54	X	X	X
10L12L	*	5.55	*	*	2.77	80.55	11.11	X	X	*
11R	X	6.25	X	1.56	X	71.87	18.75	X	X	1.6
1R12R	X	X	X	1.85	9.26	55.55	33.30	X	X	X
2R3R	X	X	6.56	3.29	X	62.29	54.84	X	X	X

Table 3. Microhabitat preference indices (PI= % use / % available) for eight radio turtles in the Lockport Prairie Nature Preserve were calculated. Microhabitat 9 has been ommitted due to the fact that no turtles were encoutered in this microhabitat. Preference indices are as follows: zero (0) no preference, 1 strongest preference for the study site.

Turtle	1	2	3	4	5	6	7	8	10
3L1R	0	0	.91	0	0	.56	1	.91	0
2L12L	0	.32	.26	1	0	.42	.37	0	0
3L10L	0	0	0	1	0	.82	.21	0	.09
3L8R	0	.07	0	.21	.84	.27	1	0	0
10L12L	0	.35	0	0	.40	1	.31	0	0
11R	0	.44	0	.10	0	1	.58	0	.025
1R12R	0	0	0	.82	1	.51	.69	0	0
2R3R	0	0	.68	.13	0	.51	1	0	0
Mean	0	.15	.23	.41	.28	.64	.65	.11	.01

Table 4. Microhabitat preference indices for 8 radio-tracked, Clemmys guttata within their home range. Percents are based on the equation PI= percent (%) use/percent (%) availability for an individuals home range. "X" symbolizes microhabitats that are absent from that turtles home range. Microhabitat 9 is not included in the table, because it is absent from all turtle home ranges. The PI values can range from zero (0) (indicating no preference for the microhabitat) to one (1) (indicating the opposite of the zero value).

Turtle	1	2	3	4	5	6	7	8	10
3L1R	X	X	.80	0	X	.22	1	.12	X
2L12L	X	1	.46	.14	0	.614	.49	X	0
3L10L	X	0	X	.69	X	1	.34	X	.29
3L8R	X	.03	X	1	.08	.22	.26	X	X
10L12L	0	.02	0	0	.18	1	.41	X	0
11R	X	.07	X	.10	X	1	.53	X	.55
1R12R	X	X	X	.34	.44	1	.57	X	X
2R3R	X	X	.12	.17	X	.50	1	X	X
Mean	0	.28	.35	.31	.18	.69	.58	.12	.21

Table 5. Home ranges of eight Clemmys guttata as determined by radio-tracking at Lockport Prairie Nature Preserve, Will Co. Illinois. (N= the number of observed relocations for an individual turtle's home range)

Turtle	Sex	Home range length (m)	N	Acres	Hectares
3L1R	F	304.4	61	4.17	1.68
2L12L	F	286.17	33	4.45	1.80
3L10L	F	201.93	63	4.89	1.98
3L8R	F	178.61	59	1.97	0.80
10L12L	F	218.7	36	6.15	2.49
11R	M	209.1	64	2.48	1.00
1R12R	M	157.88	54	1.35	0.55
2R3R	M	148.13	61	1.52	0.61

Table 6. Number and size of core areas of eight spotted turtles radio-tracked at Lockport study site.

Turtle	Sex	No.	Range	Mean	% of H.R.	Area in Ha.
3L1R	F	2	.26-.30	.28	32.90%	0.56
2L12L	F	2	.074-.092	.083	9.23%	0.166
3L10L	F	2	.05-.104	.077	7.64%	0.1.54
3L8R	F	2	.07-.213	.142	35.20%	0.283
10L12L	F	3	.007-.15	.07	9.80%	0.207
11R	M	1	.173	.173	17.30%	0.173
1R12R	M	2	.08-.125	.10	36.80%	0.205
2R3R	M	2	.011-.205	.11	35.40%	0.215

Table 7. Home range size (hectares) for radio-tagged females at the Lockport study site. Home range size has been calculated with and without nesting movements.

Turtle	Nest type or location	Total Home range	Home range excluding nesting movements
3L1R	Extreme north home range	1.68	0.30
2L12L	N.E. corner of Home range	1.80	1.27
3L10L	Center of Home range	1.98	1.98
3L8R	Laboratory Nest	0.80	0.80
10L12L	No nest	2.49	2.49
		-----	-----
	Mean	1.75 ha	1.37 ha

Table 8. Correlation coefficients and regression equations relating cloacal temperatures of basking spotted turtles to environmental temperature. All temperatures in degrees Celsius.

Temperature	N	Mean(+-SD)	Regression equation	Range
Cloacal	138	23.68(4.05)	-------------------	14.0-33.0
Air	135	21.99(3.31)	y=8.01+0.72(x) r=0.59	13.8-29.6
Water	97	17.09(3.87)	y=11.34+0.69(x) r=0.64	6.0-29.6
Substrate	45	22.07(3.21)	y=13.87+0.51(x) r=0.56	16.0-33.0

Table 9. Correlation coefficients and regression equations relating cloacal temperatures of aestivating spotted turtles to environmental temperature. All temperatures in degrees Celsius.

Temperature	N	Mean(+-SD)	Regression Equation	Range
Cloacal	23	22.42(5.92)	----------------	13.2-30.6
Air	23	24.20(5.06)	$y=-.626+.95(x)$ $r= 0.81$	13.8-31.0
Water	7	18.61(3.00)	$y=10.77+0.31(x)$ $r=0.25$	14.8-23.6
Substrate	23	19.75(4.80)	$y=-.864+1.18(x)$ $r=0.96$	10.0-27.0

Table 10. Correlation coefficients and regression equations relating cloacal temperatures of dormant spotted turtles in high temperature water to environmental temperature. All temperatures in degrees Celsius.

Temperature	N	Mean(+-SD)	Regression Equation	Range
Cloacal	4	18.5(2.67)	-------------------	15.8-22.2
Air	3	19.0(2.20)	$y=-8.97+1.45(x)$ $r=0.98$	16.8-21.2
Water	4	18.2(3.15)	$y=3.50+0.82(x)$ $r=0.97$	15.8-22.8

Table 11. Correlation coefficients and regression equations relating cloacal temperatures of dormant spotted turtles in low temperature water to environmental temperature. All temperatures in degrees Celsius.

Temperature	N	Mean(+-SD)	Regression Equation	Range
Cloacal	17	10.47(3.34)	-------------------	4.4-14.4
Air	13	14.28(3.03)	$y=1.79+0.69(x)$ $r=0.69$	6.6-17.8
Water	16	10.79(3.18)	$y=0.292+0.98(x)$ $r=0.98$	5.6-14.4

Table 12. Correlation coefficients and regression equations relating cloacal temperatures of spotted turtles moving in water to environmental temperature. All temperatures in degrees Celsius.

Temperature	N	Mean(+-SD)	Regression Equation	Range
Cloacal	49	21.31(4.76)	--------------------	12.4-31.6
Air	48	22.96(3.56)	$y=-1.66+1.00(x)$ $r=0.74$	15.2-31.4
Water	49	20.61(5.25)	$y=3.35+0.87(x)$ $r=0.96$	12.4-33.0
Substrate	3	22.56(4.56)	$y=4.04+0.85(x)$ $r=0.99$	17.8-26.9

Table 13. Correlation coefficients and regression equations relating cloacal temperatures of spotted turtles moving on land to environmental temperature. All temperatures in degrees Celsius.

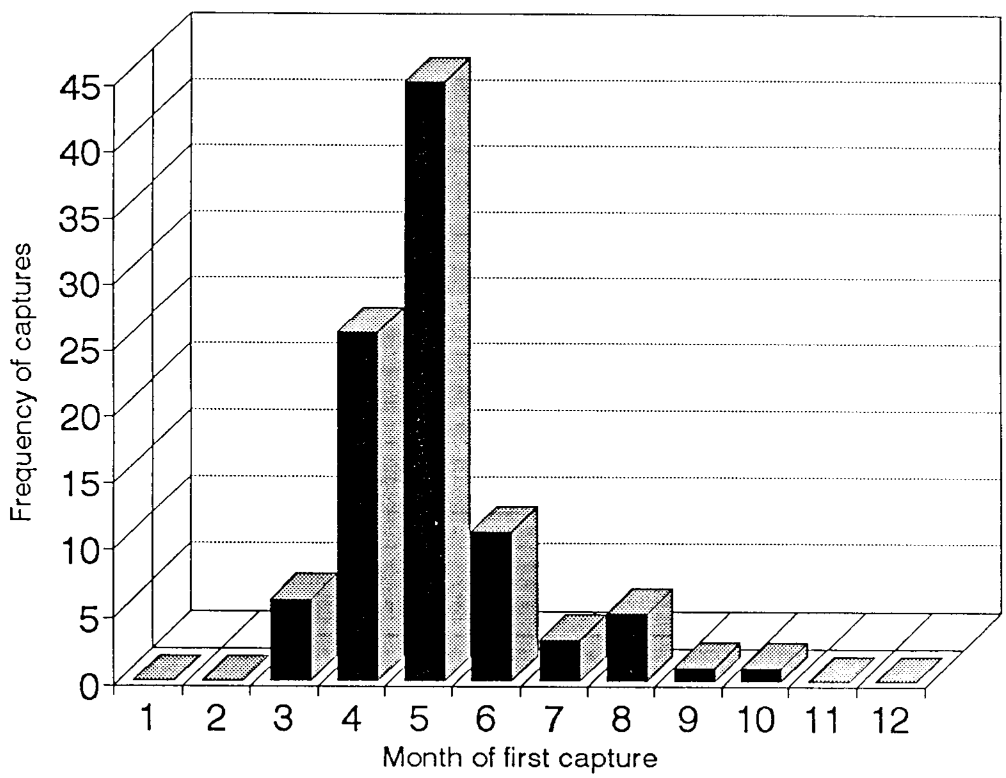
Temperature	N	Mean(+-SD)	Regression Equation	Range
Cloacal	5	23.62(7.19)	-------------------	12.1-29.0
Air	5	20.64(6.30)	y=1.59+1.07(x) r=0.93	9.6-25.2
Water	3	19.33(2.77)	y=-22.96+2.36(x) r=0.71	17.0-22.4
Substrate	4	17.6(5.01)	y=-1.15+1.33(x) r=0.88	10.2-21.2

Table 14. Plastral growth rate of sexes in spotted turtles, _Clemmys guttata_ from northeastern Illinois.

AGE	N	x	PLASTRON LENGTH IN (mm) RANGE	% INCREASE
			MALES	
0	10	25.46	19.5-40.57	-----
1	14	38.71	28.22-54.96	22.17
2	14	49.28	33.64-60.53	17.7
3	14	56.16	43.53-68.54	11.52
4	14	64.54	43.4-72.69	14.03
5	14	72.34	54.81-85.93	13.06
6	14	76.94	59.69-88.48	7.7
7	11	80.08	65.58-89.0	5.26
8	9	84.16	71.1-90.2	6.83
9	7	86.89	74.35-93.63	4.57
10	4	91.07	79.77-101.0	6.99
11	1	85.20	85.2	0.0
			FEMALES	
0	9	24.23	17.76-29.93	-----
1	10	38.20	30.8-49.68	21.4
2	10	46.64	33.0-56.22	12.9
3	10	53.44	47.39-62.95	10.4
4	10	60.50	44.55-71.3	10.8
5	10	67.59	53.9-74.14	10.8
6	10	73.38	58.3-83.2	8.85
7	10	79.32	65.45-93.86	9.1
8	9	82.29	69.85-95.38	4.54
9	8	86.87	74.25-97.56	7.0
10	6	86.40	78.1-92.34	0.0
11	3	89.63	83.6-93.1	4.94

FIGURES
(1-13)

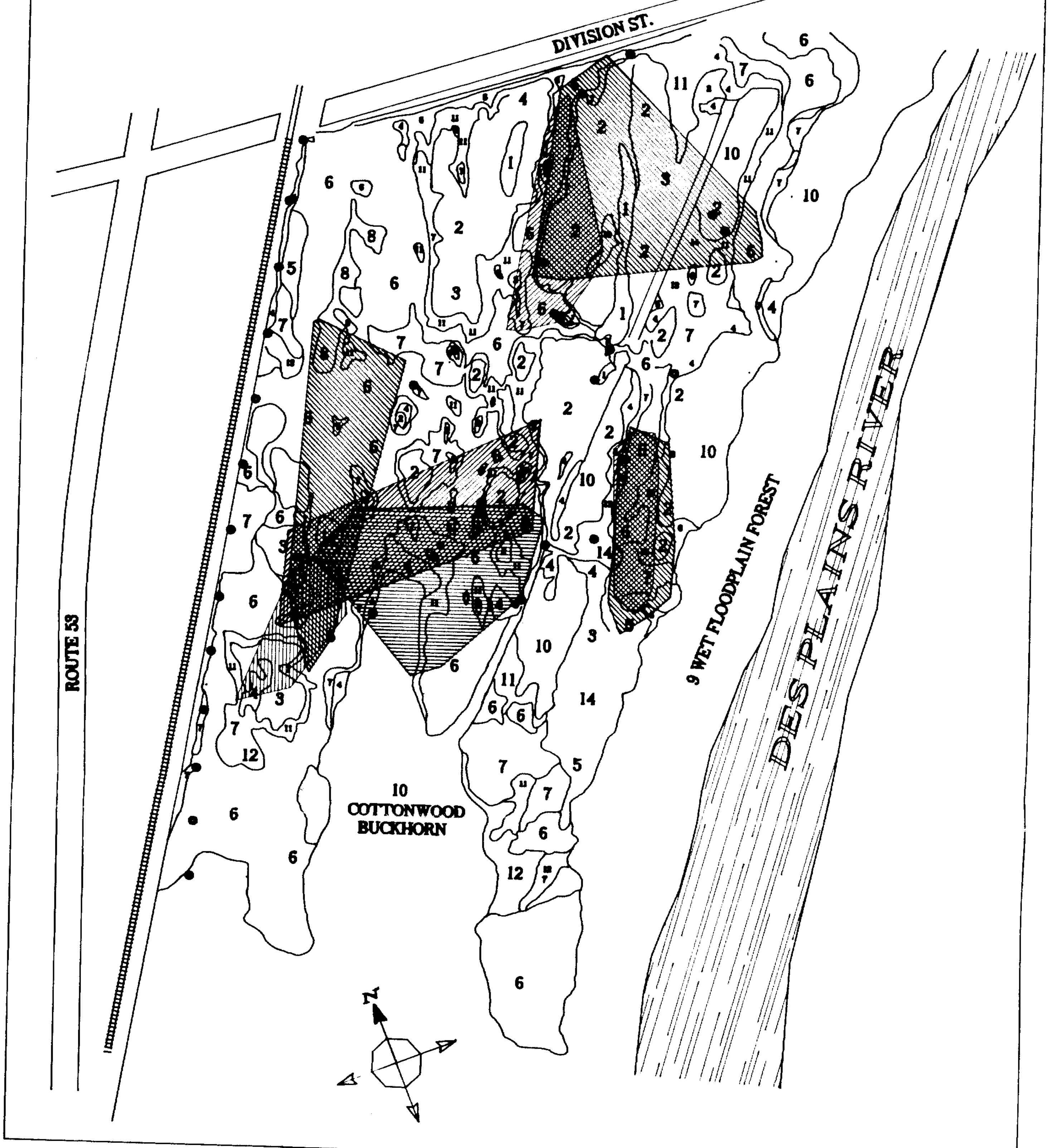
Figure 1. Frequency of spotted turtle first time captures through the years 1988-1993 (months labelled on x-axis by numbers 1-12 (i.e. January=1, February=2, March=3 ....December 12).



45
40
35
30
25
20
15
10
5
0
Frequency of captures
1
2
3
4
5
6
7
8
9
10
11
12
Month of first capture

Figure 2. Aerial map showing the eight radio turtle home ranges with respective overlap at the Lockport Prairie Nature Preserve study site with microhabitats 1-10.

MICROHABITAT BASE MAP



MICROHABITATS

1 DRY DOLOMITE PRAIRIE
2 DRY MESIC DOLOMITE PRAIRIE
3 MESIC DOLOMITE PRAIRIE
4 WET MESIC DOLOMITE PRAIRIE
5 WET DOLOMITE PRAIRIE
6 MARSH
7 SEDGE MEADOW
8 GRAMINOID FEN
9 FLOODPLAIN FOREST
10 SUCCESSIONAL-CULTURAL

* COMBINATIONS OF MICROHABITATS
11 WET MESIC DOLOMITE PRAIRIE - SEDGE MEADOW
12 MARSH - SEDGE MEADOW
13 WET DOLOMITE PRAIRIE - SEDGE MEADOW
14 WET MESIC DOLOMITE PRAIRIE - WET DOLOMITE PRAIRIE

MALE HOMERANGES

FEMALE HOMERANGES

VARIOUS REFERENCE POINTS

SCALE:

TOTAL AREA - 4,825,894 SQUARE FEET

MICROHABITAT	% OF TOTAL AREA	SQUARE FOOTAGE
1	.650%	31,500 S.F.
2	5.77%	278,587 S.F.
3	2.31%	111,371 S.F.
4	6.12%	295,254 S.F.
5	2.50%	120,585 S.F.
6	29.3%	1,413,193 S.F.
7	13.1%	626,189 S.F.
8	.584%	26,468 S.F.
9	14.3%	691,168 S.F.
10	25.5%	1,231,579 S.F.

DIGITIZED SPRING 1994 E.I.U. GEOLOGY DEPT.
by WILLIAM E. McNULTY

Figure 3. Home range of turtle 3L1R (female) throughout the annual activity cycle from May 10, 1992 to March 26, 1993 at the Lockport (south) Prairie Nature Preserve.

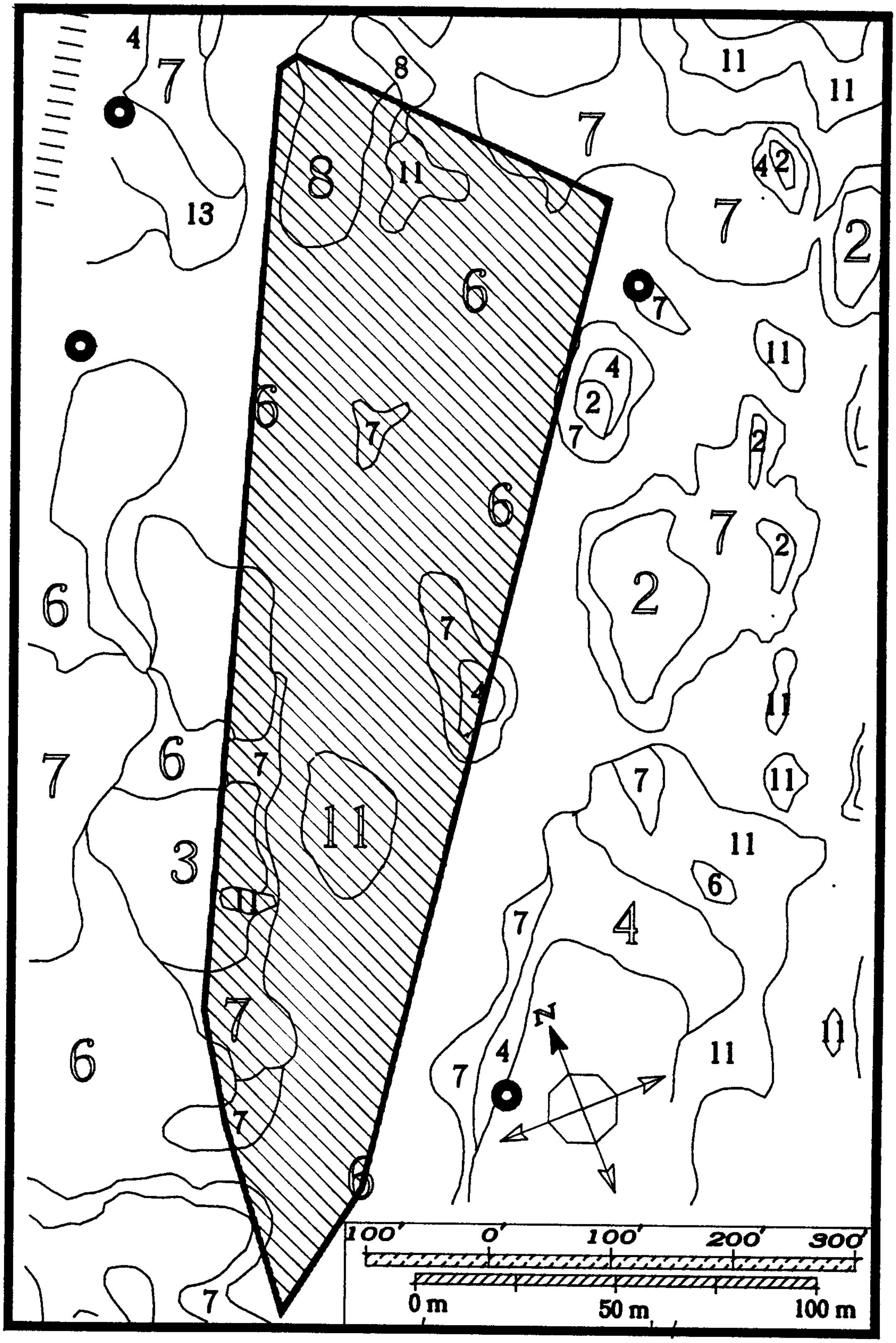

N
100' 0' 100' 200' 300'
0 m 50 m 100 m

Figure 4. Home range of 2L12L (female) throughout the summer activity cycle from May 10, 1992 to August 14, 1992 at the Lockport (south) Prairie Nature Preserve.

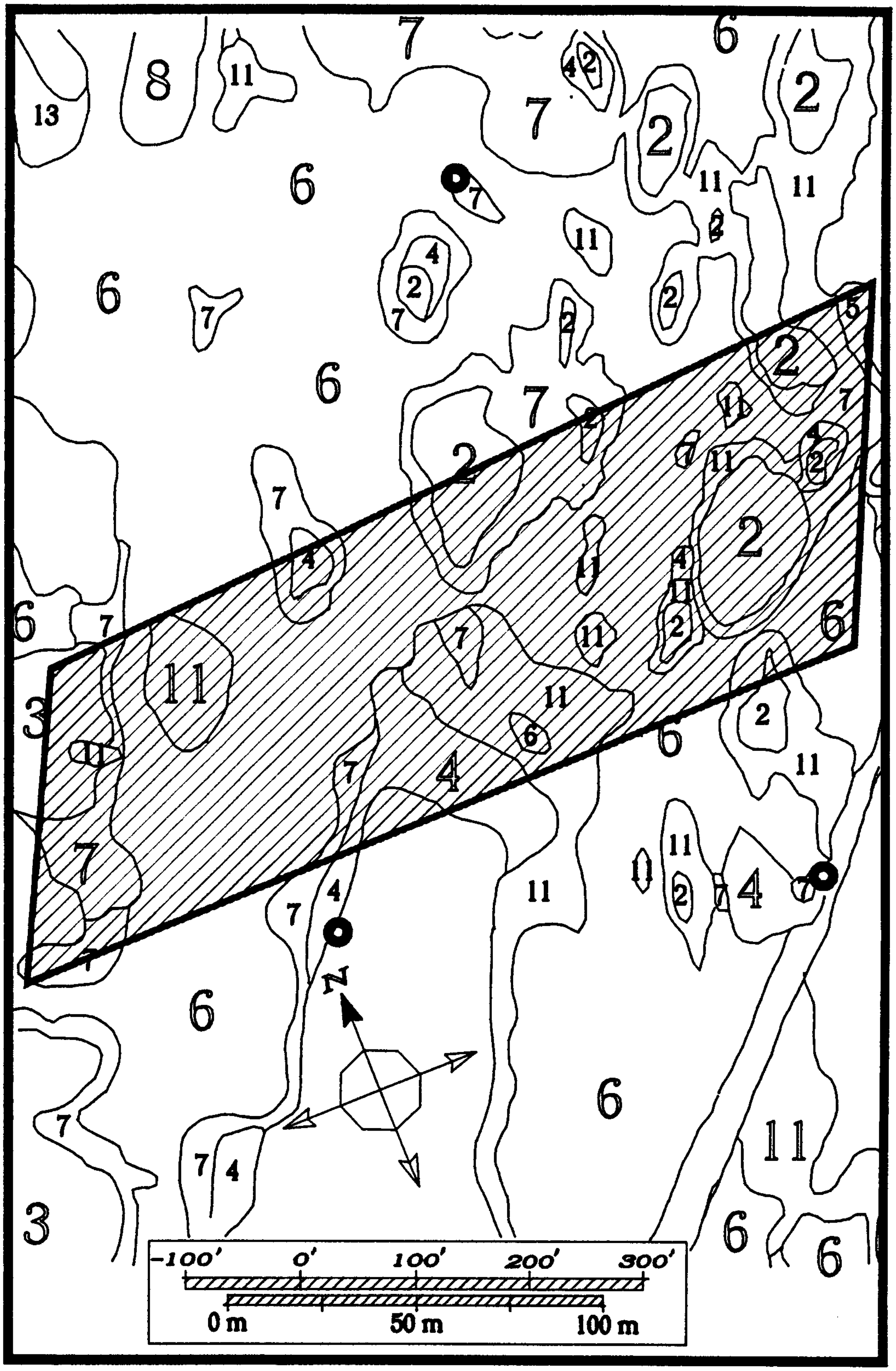
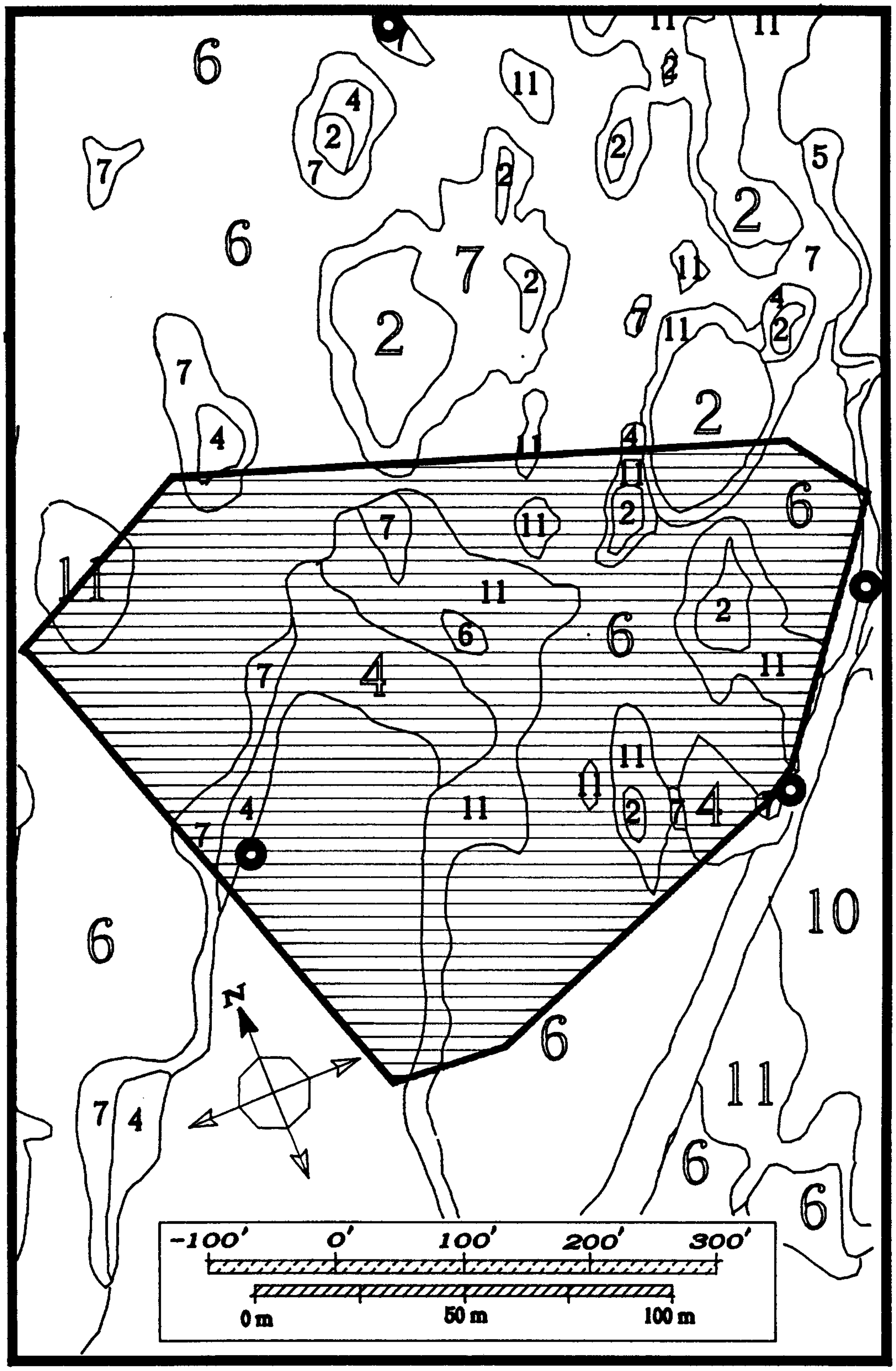

-100'
0'
100'
200'
300'
0 m
50 m
100 m
N

Figure 5. Home range of 3L10L (female) throughout the annual activity cycle from May 10, 1992 to June 26, 1993 at the Lockport (south) Prairie Nature Preserve.



-100'
0'
100'
200'
300'
0 m
50 m
100 m
N

Figure 6. Home range of 3L8R (female) throughout the annual activity cycle from May 10, 1992 to March 26, 1992 at the Lockport (south) Prairie Nature Preserve.

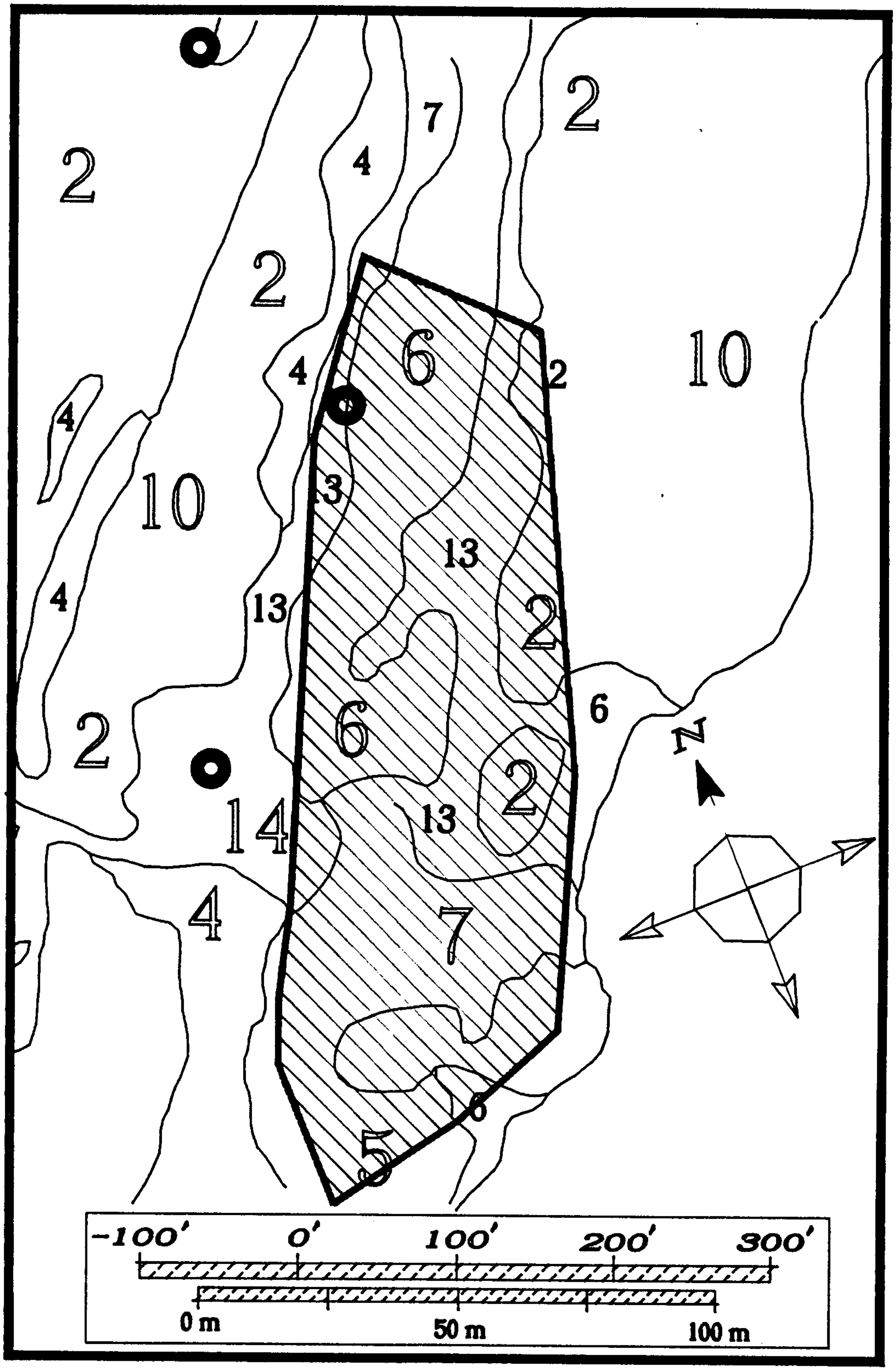

2
7
4
2
2
6
2
10
4
4
3
10
13
4
13
2
6
6
2
2
14
13
4
7
6
5
N
-100'
0'
100'
200'
300'
0 m
50 m
100 m

Figure 7. Home range of 10L12L (female) from May 10, 1992 to July 17, 1992 at Lockport (south) Prairie Nature Preserve.

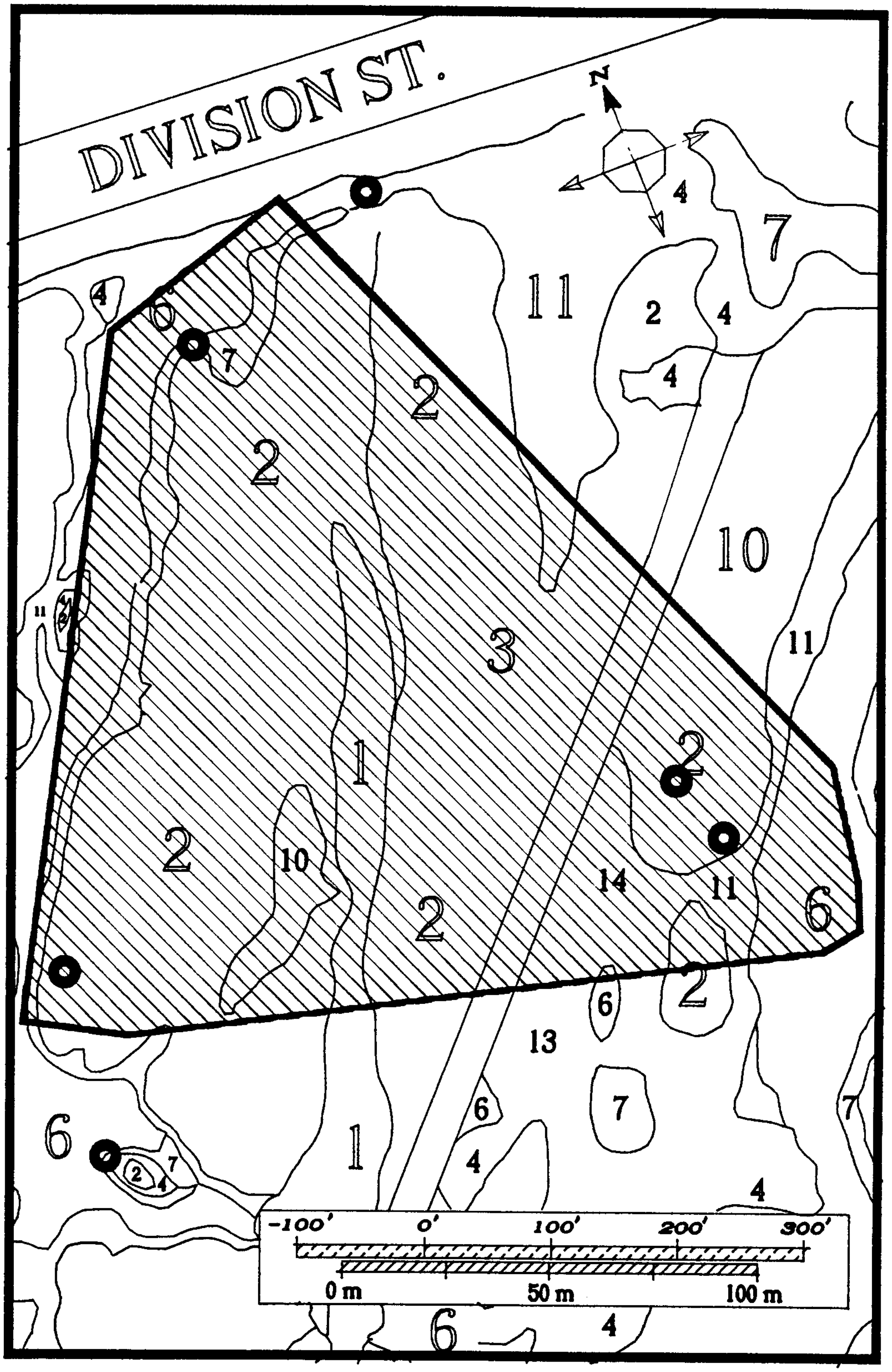

DIVISION ST.
N
-100'
0'
100'
200'
300'
0 m
50 m
100 m

Figure 8. Home range of turtle 11R (male) throughout the annual activity cycle from May 10, 1992 to March 26, 1993 at the Lockport (south) Prairie Nature Preserve.

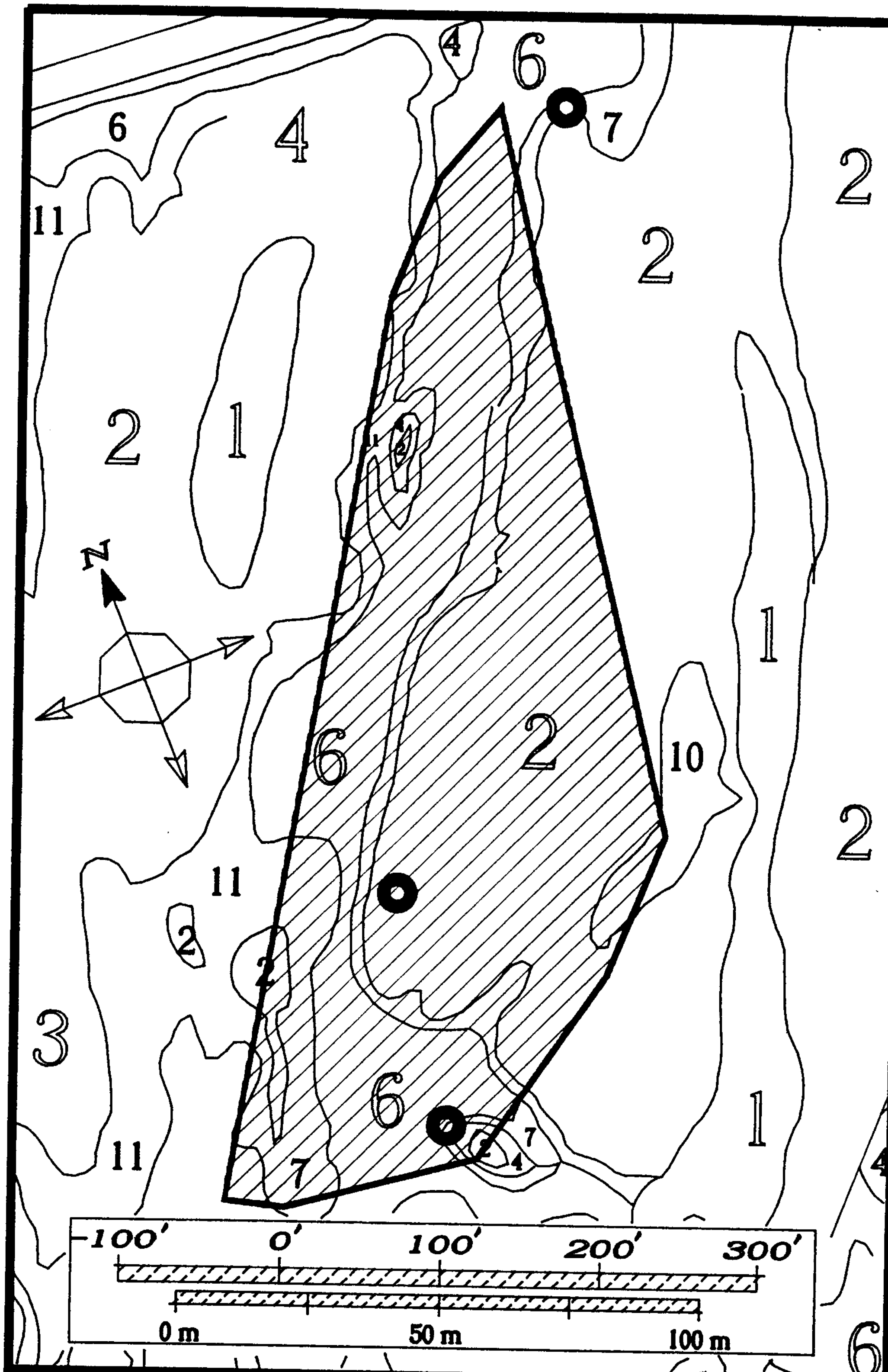
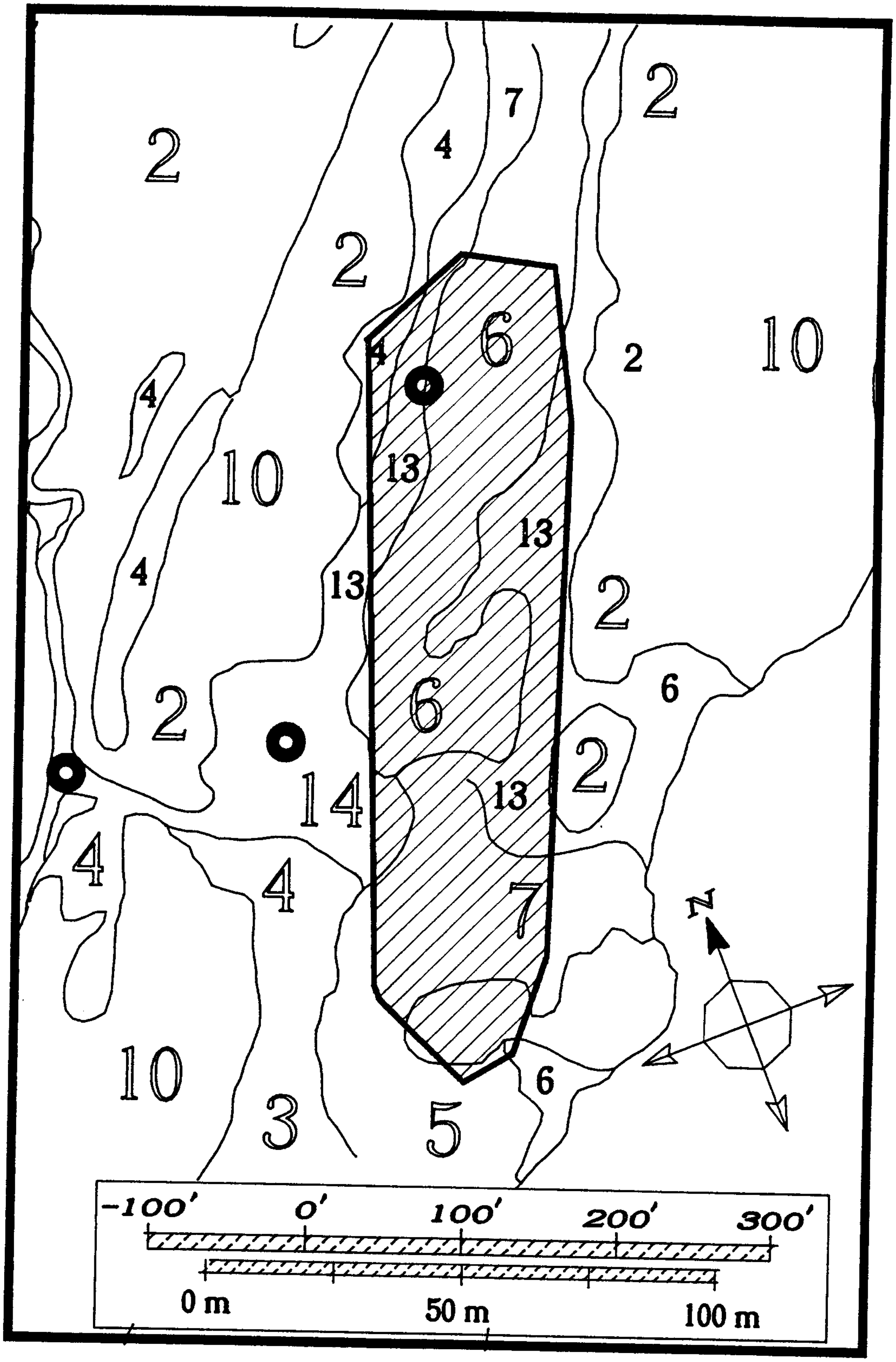

N
-100'
0'
100'
200'
300'
0 m
50 m
100 m

Figure 9. Home range of turtle 1R12R (male) throughout the annual activity cycle from May 10, 1992 to March 26, 1993 at the Lockport (south) Prairie Nature Preserve.



2
7
4
2
2
2
6
10
4
4
10
13
13
13
4
2
2
6
6
2
14
13
2
4
4
7
N
10
3
5
6
-100'
0'
100'
200'
300'
0 m
50 m
100 m

Figure 10. Home range of turtle 2R3R (male) throughout the annual activity cycle from May 10, 1992 to March 26, 1993 at the Lockport (south) Prairie Nature Preserve.

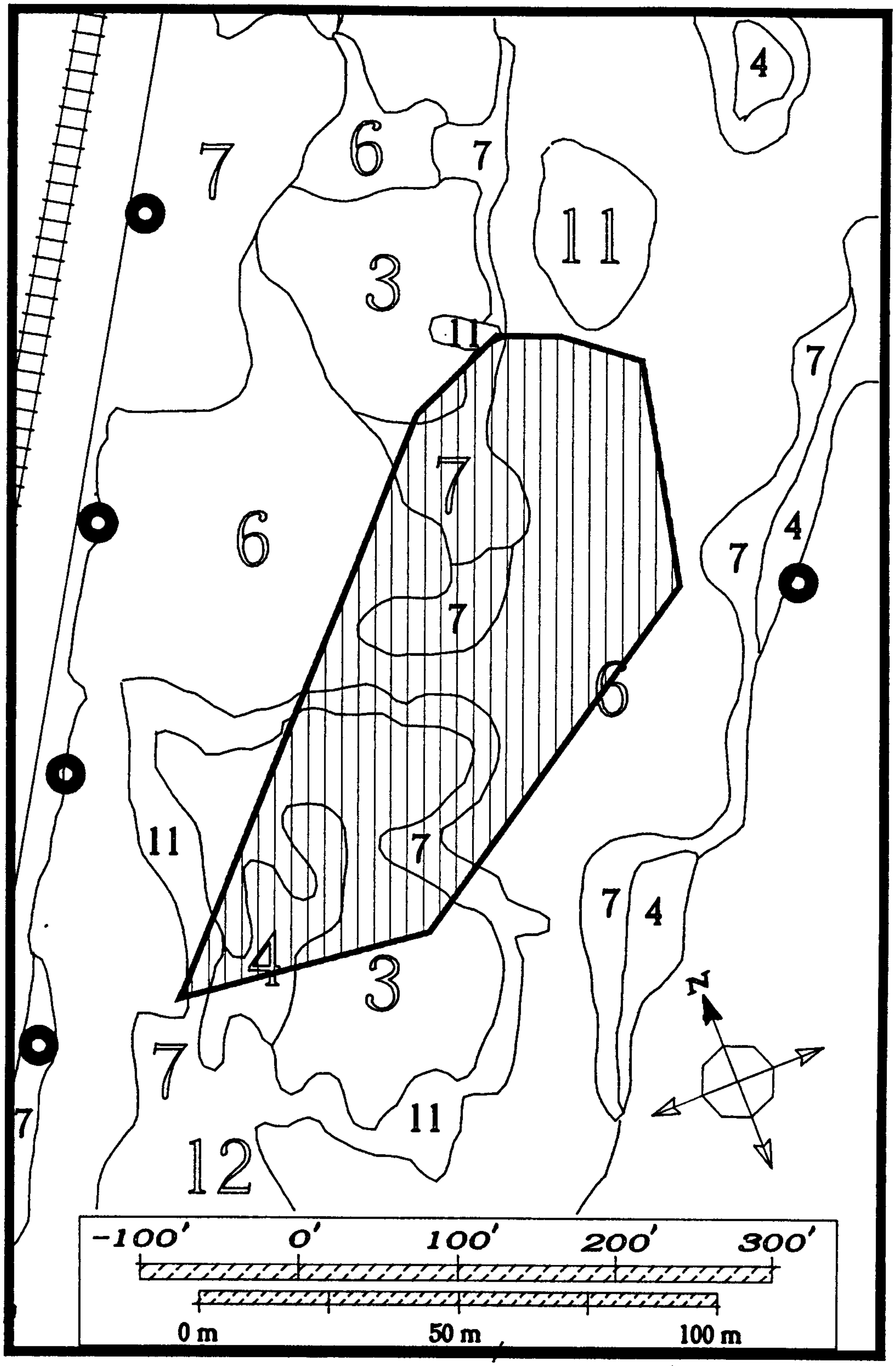

7
6
7
4
11
3
11
7
6
7
4
7
7
6
11
7
7
4
4
3
7
11
7
12
-100'
0'
100'
200'
300'
0 m
50 m
100 m
N

Figure 11. X-Ray photograph of a female 3L1R with a clutch size of 4 eggs (scale: 7.42 millimeters in photograph equals 10 millimeters in life).

Figure 12. Average plastron size for all age classes of spotted turtles represented in the sample (sexes combined). The graph illustrates the range from high to low with the horizontal tick mark representing the mean plastron size for each age class.

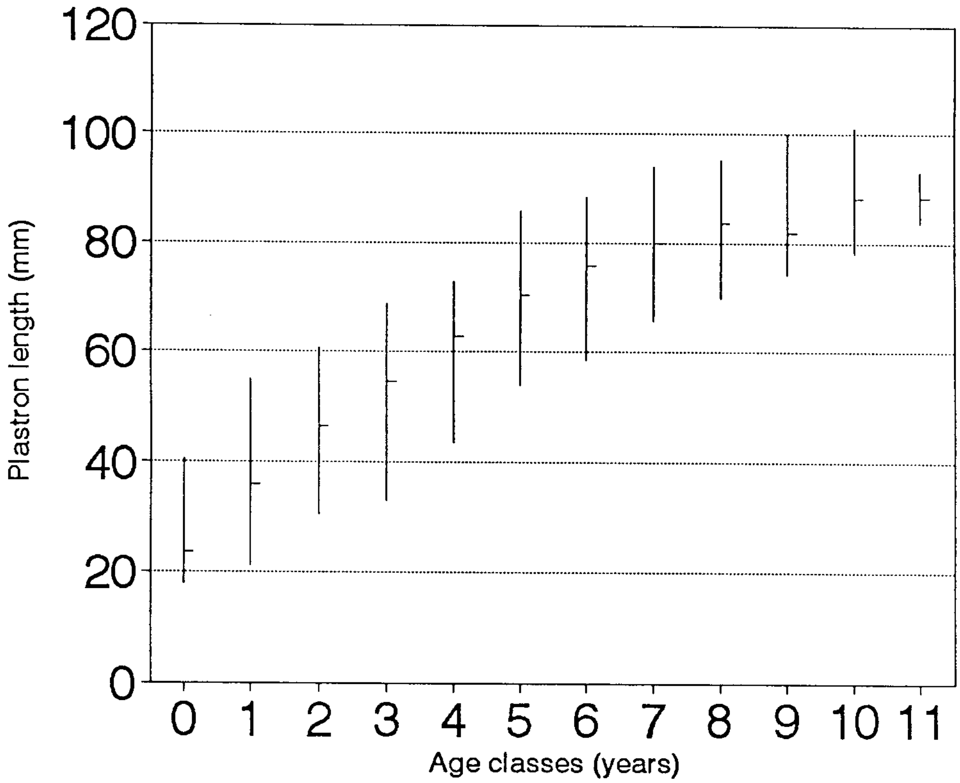
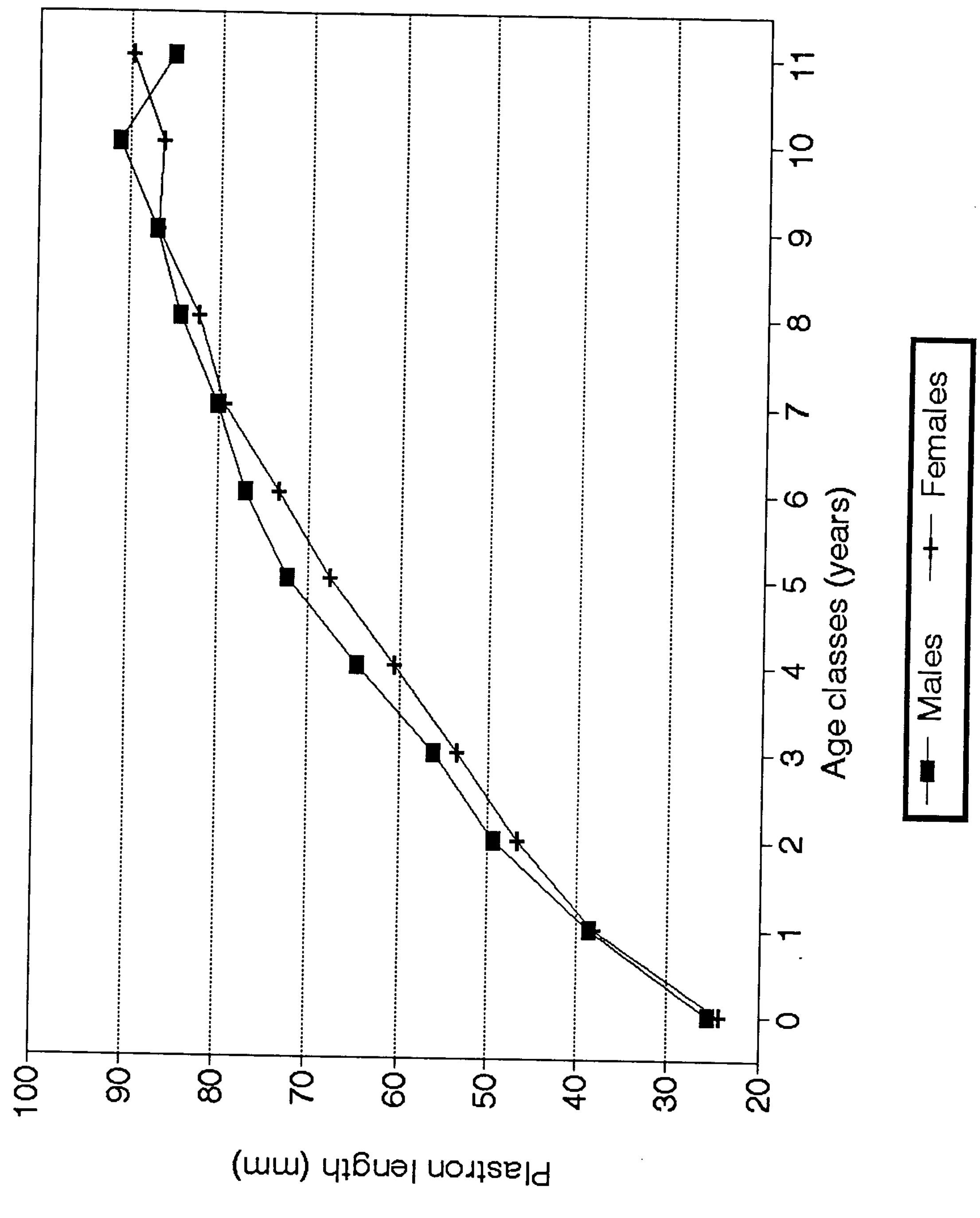

120
100
80
60
40
20
0
Plastron length (mm)
0 1 2 3 4 5 6 7 8 9 10 11
Age classes (years)

Figure 13. Average plastron size for all age classes comparing males to female sizes.


Plastron length (mm)
100
90
80
70
60
50
40
30
20
0
1
2
3
4
5
6
7
8
9
10
11
Age classes (years)
Males
Females

APPENDIX A

MICROHABITAT DESCRIPTIONS (1-10)

1. Dry dolomite prairie - This xeric microhabitat occupies the highest topographical elevation at the Lockport site. The soil is shallow with scattered areas of exposed dolomite bed rock. The herbaceous vegetation is less than 1 m in height. Dominant plant species: *Schizachyrium scoparius and Bouteloua curtipendula.*

2. Dry mesic dolomite prairie - In comparison to the dry dolomite prairie, the soil depth increases to approximately 15 cm or less with a lower elevation. More moisture is held within this microhabitat and during brief periods in the Spring standing water may be found. Maximum vegetation height increases to greater than 1 m. Plant diversity also increases. Dominant species: *Sorghastrum nutans, Schizachyrium scorparius, and Sporobolus heterolepis.*

3. Mesic dolomite prairie - Soil depth is greater than 15 cm. Standing water may remain until early summer. This microhabitat intergrade with mesic prairie. In such cases the mesic dolomite prairie lacks certain deeply rooted herbaceous plants which are present in the mesic prairie. The dominant species of plants are an intergradation between the dry mesic and wet mesic dolomite prairie.

4. Wet mesic dolomite prairie - Soil depth averages 30 cm. Standing water is present during periods throughout the year. This microhabitat is differentiated from the graminoid fen through vegetation restricted to the wet mesic dolomite prairie. Dominant species: *Andropogon gerardii, Schizachyrium scoparius, Sporobolus nutans, and Calamagrostis canadensis.*

5. Wet dolomite prairie - Soil depth is less than 15 cm with standing water present until mid to late summer. Topographical depression in this microhabitat have ample soil depth to support sedge meadow, making this a unique habitat. Dominant species: *Deschampsia caespitosa, C. canadensis, and Spartina pectinata.*

6. Marsh - Freshwater wetland microhabitat consisting of varying levels of diversity governed by water depth, shallows supporting the greatest diversity. Best destinquished from other wetland communities such as sedge meadow and graminoid fen by the species of plant life contained. Dominant species: *Typha angustifolia, T. latifolia, Scirpus validus, S. atrovirens, and S. actus*. Characteristic plants: *Alisma sp., Boltonia latisquama, Proserpinaca palustris, Sagittaria latifolia,* and *Scutellaria epilobiifolia.*

7. Sedge meadow - Moisture levels similar to that of the wet dolomite prairie. Dominant species: *Carex stricta, C. lanuginosa, C. sartwellii, C. scoparia, Calamagrostis canadensis, and Glyceria striata.* Characteristic species: *Aster lucidulus, Chelone glabra, Epilobium leptophyllym, Eupatorium maculatum, and Triadenum virginicum.*

8. Graminoid fen - Often found at the edge of marsh or sedge meadow microhabitat, due to upwelling of ground water. Dominant species: *Andropogon gerardi, Sorghastrum nutans, and Carex sterilis*. Characteristic species: *Carex hystricina, Liatris spicata, Lobelia kalmii, Lysimachia quadriflora, Muhlenbergia glomerata, Parnassia glauca, and Solidago ohioensis.*

9. Floodplain forest - Frequently flooded forest area along Des Plaines River.

Dolomite bed rock exposed in some areas. Dominant species: *Acer saccharinum* , *Salix nigra, and Fraxinus pennsylvanica subintergerrima.*

10. Successional cultural - These areas were heavily grazed and disturbed by human use, causing a large reduction in the quality of native plant diversity. Dominant species: *Poa compressa, and Poa pratensis*. (For an aerial perspective for microhabitats 1-10 see Figure 2).